S.I.A

REPORT

OF THE

SIXTY-FIFTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

HELD AT

IPSWICH IN SEPTEMBER 1895.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
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CONTENTS.

REPORTS ON THE STATE OF SCIENCE.

[*An asterisk * indicates that the title only is given. The mark † indicates the same, but a reference is given to the journal or newspaper where it is published* in extenso.]

Page

TRANSACTIONS OF THE SECTIONS.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

A joint Meeting with Section B.

SATURDAY, SEPTEMBER 14.

I. MATHEMATICS.

TUESDAY, SEPTEMBER 17.

WEDNESDAY, SEPTEMBER 18.

SECTION B.—CHEMISTRY.

THURSDAY SEPTEMBER 12.

MONDAY, SEPTEMBER 16.

TUESDAY, SEPTEMBER 17.

SECTION C.—GEOLOGY.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

SATURDAY, SEPTEMBER 14.

MONDAY, SEPTEMBER 16.

FRIDAY, SEPTEMBER 13.

MONDAY, SEPTEMBER 16.

TUESDAY, SEPTEMBER 17.

Section E.—GEOGRAPHY.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

MONDAY, SEPTEMBER 16.

TUESDAY, SEPTEMBER 17.

Section F.—ECONOMIC SCIENCE AND STATISTICS.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

MONDAY, SEPTEMBER 16.

TUESDAY, SEPTEMBER 17.

SECTION G.—MECHANICAL SCIENCE.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

FRIDAY, SEPTEMBER 13.

SATURDAY, SEPTEMBER 14.

MONDAY, SEPTEMBER 16.

TUESDAY, SEPTEMBER 17.

WEDNESDAY, SEPTEMBER 18.

Section K.—BOTANY.

THURSDAY, SEPTEMBER 12.

FRIDAY, SEPTEMBER 13.

MONDAY, SEPTEMBER 16.

†Joint Discussion with Section B was held on the Relation of Agriculture to Science.

TUESDAY, SEPTEMBER 17.

LIST OF PLATES.

ERRATUM.

In 1884 (*Montreal*) *Report*

Page 288, Table, second column. For 44 *read* 47.

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

THE ASSOCIATION contemplates no interference with the ground occupied by other institutions. Its objects are:—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

Admission of Members and Associates.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

Compositions, Subscriptions, and Privileges.

LIFE MEMBERS shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

ANNUAL SUBSCRIBERS shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*; but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the offices of the Association.

ASSOCIATES for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.
2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.
3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]
4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]
5. Associates for the year, subject to the payment of One Pound.
6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members *who have not intermitted* their Annual Subscription.
2. *At reduced or Members' Price*, viz., two-thirds of the Publication Price. —Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]
3. Members may purchase (for the purpose of completing their sets) any of the volumes of the Reports of the Association up to 1874, *of which more than* 15 *copies remain*, at 2*s*. 6*d*. per volume.[1]

Application to be made at the Office of the Association.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

Subscriptions shall be received by the Treasurer or Secretaries.

[1] A few complete sets, 1831 to 1874, are on sale, at £10 the set.

Meetings.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee two years in advance; and the arrangements for it shall be entrusted to the Officers of the Association.

General Committee.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

CLASS A. PERMANENT MEMBERS.

1. Members of the Council, Presidents of the Association, and Presidents of Sections for the present and preceding years, with Authors of Reports in the Transactions of the Association.

2. Members who by the publication of Works or Papers have furthered the advancement of those subjects which are taken into consideration at the Sectional Meetings of the Association. *With a view of submitting new claims under this Rule to the decision of the Council, they must be sent to the Assistant General Secretary at least one month before the Meeting of the Association. The decision of the Council on the claims of any Member of the Association to be placed on the list of the General Committee to be final.*

CLASS B. TEMPORARY MEMBERS.[1]

1. Delegates nominated by the Corresponding Societies under the conditions hereinafter explained. *Claims under this Rule to be sent to the Assistant General Secretary before the opening of the Meeting.*

2. Office-bearers for the time being, or delegates, altogether not exceeding three, from Scientific Institutions established in the place of Meeting. *Claims under this Rule to be approved by the Local Secretaries before the opening of the Meeting.*

3. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing, for the Meeting of the year, by the President and General Secretaries.

4. Vice-Presidents and Secretaries of Sections.

Organising Sectional Committees.[2]

The Presidents, Vice-Presidents, and Secretaries of the several Sections are nominated by the Council, and have power to act until their names are submitted to the General Committee for election.

From the time of their nomination they constitute Organising Committees for the purpose of obtaining information upon the Memoirs and Reports likely to be submitted to the Sections,[3] and of preparing Reports

[1] Revised by the General Committee, 1884.

[2] Passed by the General Committee, Edinburgh, 1871.

[3] *Notice to Contributors of Memoirs.*—Authors are reminded that, under an arrangement dating from 1871, the acceptance of Memoirs, and the days on which they are to be read, are now as far as possible determined by Organising Committees for the several Sections *before the beginning of the Meeting.* It has therefore become

thereon, and on the order in which it is desirable that they should be read, to be presented to the Committees of the Sections at their first meeting. The Sectional Presidents of former years are *ex officio* members of the Organising Sectional Committees.[1]

An Organising Committee may also hold such preliminary meetings as the President of the Committee thinks expedient, but shall, under any circumstances, meet on the first Wednesday of the Annual Meeting, at 11 A.M., to nominate the first members of the Sectional Committee, if they shall consider it expedient to do so, and to settle the terms of their report to the Sectional Committee, after which their functions as an Organising Committee shall cease.[2]

Constitution of the Sectional Committees.[3]

On the first day of the Annual Meeting, the President, Vice-Presidents, and Secretaries of each Section having been appointed by the General Committee, these Officers, and those previous Presidents and Vice-Presidents of the Section who may desire to attend, are to meet, at 2 P.M., in their Committee Rooms, and enlarge the Sectional Committees by selecting individuals from among the Members (not Associates) present at the Meeting whose assistance they may particularly desire. The Sectional Committees thus constituted shall have power to add to their number from day to day.

The List thus formed is to be entered daily in the Sectional Minute-Book, and a copy forwarded without delay to the Printer, who is charged with publishing the same before 8 A.M. on the next day in the Journal of the Sectional Proceedings.

Business of the Sectional Committees.

Committee Meetings are to be held on the Wednesday, and on the following Thursday, Friday, Saturday,[4] Monday, and Tuesday, for the objects stated in the Rules of the Association. The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and the Sectional Committee except for Thursday and Saturday.[5]

The business is to be conducted in the following manner:—

1. The President shall call on the Secretary to read the minutes of the previous Meeting of the Committee.
2. No paper shall be read until it has been formally accepted by the

necessary, in order to give an opportunity to the Committees of doing justice to the several Communications, that each author should prepare an Abstract of his Memoir of a length suitable for insertion in the published Transactions of the Association, and that he should send it, together with the original Memoir, by book-post, on or before........................, addressed to the General Secretaries, at the office of the Association. 'For Section.........' If it should be inconvenient to the Author that his paper should be read on any particular days, he is requested to send information thereof to the Secretaries in a separate note. Authors who send in their MSS. three complete weeks before the Meeting, and whose papers are accepted, will be furnished, before the Meeting, with printed copies of their Reports and abstracts. No Report, Paper, or Abstract can be inserted in the Annual Volume unless it is handed either to the Recorder of the Section or to the Assistant General Secretary *before the conclusion of the Meeting.*

[1] Sheffield, 1879. [2] Swansea, 1880. [3] Edinburgh, 1871.
[4] The meeting on Saturday is optional, Southport, 1883. [5] Nottingham, 1893.

Committee of the Section, and entered on the minutes accordingly.

3. Papers which have been reported on unfavourably by the Organising Committees shall not be brought before the Sectional Committees.[1]

At the first meeting, one of the Secretaries will read the Minutes of last year's proceedings, as recorded in the Minute-Book, and the Synopsis of Recommendations adopted at the last Meeting of the Association and printed in the last volume of the Report. He will next proceed to read the Report of the Organising Committee.[2] The list of Communications to be read on Thursday shall be then arranged, and the general distribution of business throughout the week shall be provisionally appointed. At the close of the Committee Meeting the Secretaries shall forward to the Printer a List of the Papers appointed to be read. The Printer is charged with publishing the same before 8 A.M. on Thursday in the Journal.

On the second day of the Annual Meeting, and the following days, the Secretaries are to correct, on a copy of the Journal, the list of papers which have been read on that day, to add to it a list of those appointed to be read on the next day, and to send this copy of the Journal as early in the day as possible to the Printer, who is charged with printing the same before 8 A.M. next morning in the Journal. It is necessary that one of the Secretaries of each Section (generally the Recorder) should call at the Printing Office and revise the proof each evening.

Minutes of the proceedings of every Committee are to be entered daily in the Minute-Book, which should be confirmed at the next meeting of the Committee.

Lists of the Reports and Memoirs read in the Sections are to be entered in the Minute-Book daily, which, with *all Memoirs and Copies or Abstracts of Memoirs furnished by Authors, are to be forwarded, at the close of the Sectional Meetings*, to the Assistant General Secretary.

The Vice-Presidents and Secretaries of Sections become *ex officio* temporary Members of the General Committee (*vide* p. xxix), and will receive, on application to the Treasurer in the Reception Room, Tickets entitling them to attend its Meetings.

The Committees will take into consideration any suggestions which may be offered by their Members for the advancement of Science. They are specially requested to review the recommendations adopted at preceding Meetings, as published in the volumes of the Association, and the communications made to the Sections at this Meeting, for the purposes of selecting definite points of research to which individual or combined exertion may be usefully directed, and branches of knowledge on the state and progress of which Reports are wanted; to name individuals or Committees for the execution of such Reports or researches; and to state whether, and to what degree, these objects may be usefully advanced by the appropriation of the funds of the Association, by application to Government, Philosophical Institutions, or Local Authorities.

In case of appointment of Committees for special objects of Science, it is expedient that *all Members of the Committee should be named, and*

[1] These rules were adopted by the General Committee, Plymouth, 1877.

[2] This and the following sentence were added by the General Committee, Edinburgh, 1871.

one of them appointed to act as Chairman, who shall have notified personally or in writing his willingness to accept the office, the Chairman to have the responsibility of receiving and disbursing the grant (if any has been made) and securing the presentation of the Report in due time; and, further, it is expedient that one of the members should be appointed to act as Secretary, for ensuring attention to business.

That it is desirable that the number of Members appointed to serve on a Committee should be as small as is consistent with its efficient working.

That a tabular list of the Committees appointed on the recommendation of each Section should be sent each year to the Recorders of the several Sections, to enable them to fill in the statement whether the several Committees appointed on the recommendation of their respective Sections had presented their reports.

That on the proposal to recommend the appointment of a Committee for a special object of science having been adopted by the Sectional Committee, the number of Members of such Committee be then fixed, but that the Members to serve on such Committee be nominated and selected by the Sectional Committee at a subsequent meeting.[1]

Committees have power to add to their number persons whose assistance they may require.

The recommendations adopted by the Committees of Sections are to be registered in the Forms furnished to their Secretaries, and one Copy of each is to be forwarded, without delay, to the Assistant General Secretary for presentation to the Committee of Recommendations. *Unless this be done, the Recommendations cannot receive the sanction of the Association.*

N.B.—Recommendations which may originate in any one of the Sections must *first be sanctioned by the Committee of that Section* before they can be referred to the Committee of Recommendations or confirmed by the General Committee.

Notices regarding Grants of Money.[2]

1. No Committee shall raise money in the name or under the auspices of the British Association without special permission from the General Committee to do so; and no money so raised shall be expended except in accordance with the Rules of the Association.
2. In grants of money to Committees the Association does not contemplate the payment of personal expenses to the Members.
3. Committees to which grants of money are entrusted by the Association for the prosecution of particular Researches in Science are appointed for one year only. If the work of a Committee cannot be completed in the year, and if the Sectional Committee desire the work to be continued, application for the reappointment of the Committee for another year must be made at the next meeting of the Association.
4. Each Committee is required to present a Report, whether final or interim, at the next meeting of the Association after their appointment or reappointment. InterimReports must be submitted in writing, though not necessarily for publication.

[1] Revised by the General Committee, Bath, 1888.
[2] Revised by the General Committee at Ipswich, 1895.

5. In each Committee the Chairman is the only person entitled to call on the Treasurer, Professor A. W. Rücker, F.R.S., for such portion of the sums granted as may from time to time be required.
6. Grants of money sanctioned at a meeting of the Association expire on June 30 following. The Treasurer is not authorised after that date to allow any claims on account of such grants.
7. The Chairman of a Committee must, before the meeting of the Association next following after the appointment or reappointment of the Committee, forward to the Treasurer a statement of the sums which have been received and expended, with vouchers. The Chairman must also return the balance of the grant, if any, which has been received and not spent; or, if further expenditure is contemplated, he must apply for leave to retain the balance.
8. When application is made for a Committee to be reappointed, and to retain the balance of a former grant which is in the hands of the Chairman, and also to receive a further grant, the amount of such further grant is to be estimated as being additional to, and not inclusive of, the balance proposed to be retained.
9. The Committees of the Sections shall ascertain whether a Report has been made by every Committee appointed at the previous Meeting to whom a sum of money has been granted, and shall report to the Committee of Recommendations in every case where no such report has been received.
10. Members and Committees who may be entrusted with sums of money for collecting specimens of Natural History are requested to reserve the specimens so obtained to be dealt with by authority of the Association.
11. Committees are requested to furnish a list of any apparatus which may have been purchased out of a grant made by the Association, and to state whether the apparatus will be useful for continuing the research in question, or for other scientific purposes.
12. All Instruments, Papers, Drawings, and other property of the Association are to be deposited at the Office of the Association when not employed in scientific inquiries for the Association.

Business of the Sections.

The Meeting Room of each Section is opened for conversation shortly before the meeting commences. *The Section Rooms and approaches thereto can be used for no notices, exhibitions, or other purposes than those of the Association.*

At the time appointed the Chair will be taken,[1] and the reading of communications, in the order previously made public, commenced.

Sections may, by the desire of the Committees, divide themselves into Departments, as often as the number and nature of the communications delivered in may render such divisions desirable.

[1] The Organising Committee of a Section is empowered to arrange the hours of meeting of the Section and Sectional Committee, except for Thursday and Saturday.

A Report presented to the Association, and read to the Section which originally called for it, may be read in another Section, at the request of the Officers of that Section, with the consent of the Author.

Duties of the Doorkeepers.

1. To remain constantly at the Doors of the Rooms to which they are appointed during the whole time for which they are engaged.
2. To require of every person desirous of entering the Rooms the exhibition of a Member's, Associate's, or Lady's Ticket, or Reporter's Ticket, signed by the Treasurer, or a Special Ticket signed by the Assistant General Secretary.
3. Persons unprovided with any of these Tickets can only be admitted to any particular Room by order of the Secretary in that Room.

No person is exempt from these Rules, except those Officers of the Association whose names are printed in the Programme, p. 1.

Duties of the Messengers.

To remain constantly at the Rooms to which they are appointed during the whole time for which they are engaged, except when employed on messages by one of the Officers directing these Rooms.

Committee of Recommendations.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

Presidents of the Association in former years are *ex officio* members of the Committee of Recommendations.[1]

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee unless previously recommended by the Committee of Recommendations.

All proposals for establishing new Sections, or altering the titles of Sections, or for any other change in the constitutional forms and fundamental rules of the Association, shall be referred to the Committee of Recommendations for a report.[2]

If the President of a Section is unable to attend a meeting of the Committee of Recommendations, the Sectional Committee shall be authorised to appoint a Vice-President, or, failing a Vice-President, some other member of the Committee, to attend in his place, due notice of the appointment being sent to the Assistant General Secretary.[3]

[1] Passed by the General Committee at Newcastle, 1863.
[2] Passed by the General Committee at Birmingham, 1865.
[3] Passed by the General Committee at Leeds, 1890.

Corresponding Societies.[1]

1. Any Society is eligible to be placed on the List of Corresponding Societies of the Association which undertakes local scientific investigations, and publishes notices of the results.

2. Application may be made by any Society to be placed on the List of Corresponding Societies. Applications must be addressed to the Assistant General Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended they should be considered, and must be accompanied by specimens of the publications of the results of the local scientific investigations recently undertaken by the Society.

3. A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee for the purpose of considering these applications, as well as for that of keeping themselves generally informed of the annual work of the Corresponding Societies, and of superintending the preparation of a list of the papers published by them. This Committee shall make an annual report to the General Committee, and shall suggest such additions or changes in the List of Corresponding Societies as they may think desirable.

4. Every Corresponding Society shall return each year, on or before the 1st of June, to the Assistant General Secretary of the Association, a schedule, properly filled up, which will be issued by him, and which will contain a request for such particulars with regard to the Society as may be required for the information of the Corresponding Societies Committee.

5. There shall be inserted in the Annual Report of the Association a list, in an abbreviated form, of the papers published by the Corresponding Societies during the past twelve months which contain the results of the local scientific work conducted by them; those papers only being included which refer to subjects coming under the cognisance of one or other of the various Sections of the Association.

6. A Corresponding Society shall have the right to nominate any one of its members, who is also a Member of the Association, as its delegate to the Annual Meeting of the Association, who shall be for the time a Member of the General Committee.

Conference of Delegates of Corresponding Societies.

7. The Conference of Delegates of Corresponding Societies is empowered to send recommendations to the Committee of Recommendations for their consideration, and for report to the General Committee.

8. The Delegates of the various Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairmen, and Secretaries shall be annually nominated by the Council, and appointed by the General Committee, and of which the members of the Corresponding Societies Committee shall be *ex officio* members.

9. The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the meetings.

10. The Secretaries of each Section shall be instructed to transmit to

[1] Passed by the General Committee, 1884.

the Secretaries of the Conference of Delegates copies of any recommendations forwarded by the Presidents of Sections to the Committee of Recommendations bearing upon matters in which the co-operation of Corresponding Societies is desired; and the Secretaries of the Conference of Delegates shall invite the authors of these recommendations to attend the meetings of the Conference and give verbal explanations of their objects and of the precise way in which they would desire to have them carried into effect.

11. It will be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they and others who take part in the meetings may be able to bring those recommendations clearly and favourably before their respective Societies. The Conference may also discuss propositions bearing on the promotion of more systematic observation and plans of operation, and of greater uniformity in the mode of publishing results.

Local Committees.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

Officers.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer shall be annually appointed by the General Committee.

Council.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

(1) The Council shall consist of [1]

1. The Trustees.
2. The past Presidents.
3. The President and Vice-Presidents for the time being.
4. The President and Vice-Presidents elect.
5. The past and present General Treasurers, General and Assistant General Secretaries.
6. The Local Treasurer and Secretaries for the ensuing Meeting.
7. Ordinary Members.

(2) The Ordinary Members shall be elected annually from the General Committee.

(3) There shall be not more than twenty-five Ordinary Members, of

[1] Passed by the General Committee at Belfast, 1874.

whom not more than twenty shall have served on the Council, as Ordinary Members, in the previous year.

(4) In order to carry out the foregoing rule, the following Ordinary Members of the outgoing Council shall at each annual election be ineligible for nomination:—1st, those who have served on the Council for the greatest number of consecutive years; and, 2nd, those who, being resident in or near London, have attended the fewest number of Meetings during the year —observing (as nearly as possible) the proportion of three by seniority to two by least attendance.

(5) The Council shall submit to the General Committee in their Annual Report the names of the Members of the General Committee whom they recommend for election as Members of Council.

(6) The Election shall take place at the same time as that of the Officers of the Association.

Papers and Communications.

The Author of any paper or communication shall be at liberty reserve his right of property therein.

Accounts.

The Accounts of the Association shall be audited annually, by Auditors appointed by the General Committee.

Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S. L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.

The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	The Earl of Listowel. Viscount Adare. Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S.	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S. L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal IPSWICH, July 2, 1851	The Lord Rendlesham, M.P. The Lord Bishop of Norwich Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S. L. & E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.

The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, Esq., LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, Esq., M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugell, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S., F.R.S.E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, Esq., LL.D.
RICHARD OWEN, Esq., M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, Esq., M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. Joseph Whitworth, Esq., F.R.S., M.Inst.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S. G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Rev. the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford. BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Rev. the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M.P. F. Osler, Esq., F.R.S. J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S. F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S., F.R.S.E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S. L. & E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk His Grace the Duke of Richmond, K.G., P.C., D.C.L. His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. The Right Hon. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. The Rev. Dr. Henry. Dr. Andrews, F.R.S. The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M.Inst.C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.

PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S., F.R.S.E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S., F.R.S.E. Professor Allen Thomson, M.D., LL.D., F.R.S., F.R.S.E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.
PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S., F.R.S.E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S., F.R.S.E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clif ton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom, and of the Museum of Practical Geology SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S. L. & E. Professor Allman, M.D., LL.D., F.R.S. L. & E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.

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C. W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John E. Le Feuvre, Esq. Morris Miles, Esq.
ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge SOUTHPORT, September 19, 1883.	The Right Hon. the Earl of Derby, M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	J. H. Ellis, Esq. Dr. Vernon. T. W. Willis, Esq.
The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. MONTREAL, August 27, 1884.	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., F.R.S.L. & E. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. The Hon. Dr. Chauveau Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B. M.P., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. ABERDEEN, September 9, 1885.	His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen The Right Hon. the Earl of Aberdeen, LL.D., Lord-Lieutenant of Aberdeenshire The Right Hon. the Earl of Crawford and Balcarres, M.A., LL.D., F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S., F.R.S.E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., Pres. Z.S., F.G.S., Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	J. W. Crombie, Esq., M.A. Angus Fraser, Esq., M.A., M.D., F.C.S. Professor G. Pirie, M.A.

SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada BIRMINGHAM, September 1, 1886.	The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire. The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire. The Right Hon. Lord Norton, K.C.M.G. The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire The Right Rev. the Lord Bishop of Worcester, D.D. Thomas Martineau, Esq., Mayor of Birmingham Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S. Professor W. A. Tilden, D.Sc., F.R.S., F.C.S. Rev. A. R. Vardy, M.A. Rev. H. W. Watson, D.Sc., F.R.S.	J. Barham Carslake, Esq. Rev. H. W. Crosskey, LL.D., F.G.S. Charles J. Hart, Esq.
SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somerset The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. Colonel R. P. Laurie, C.B., M.P. E. R. Wodehouse, Esq., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum. NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland. The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale, M.A.
SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., P.P.C.S., Hon. M.Inst.C.E. LEEDS, September 3, 1890.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., F.R.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. The Mayor of Leeds Sir James Kitson, Bart., M.Inst.C.E. Sir Andrew Fairbairn, M.A.	J. Rawlinson Ford, Esq. Sydney Lupton, Esq., M.A. Professor L. C. Miall, F.L.S., F.G.S. Professor A. Smithells, B.Sc.
WILLIAM HUGGINS, Esq., D.C.L., LL.D., Ph.D., F.R.S., F.R.A.S., Hon. F.R.S.E. CARDIFF, August 19, 1891.	The Right Hon. Lord Windsor, Lord-Lieutenant of Glamorganshire The Most Hon. the Marquess of Bute, K.T. The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S. The Right Hon. Lord Tredegar The Right Hon. Lord Aberdare, G.C.B., F.R.S., F.R.G.S. Sir J. T. D. Llewelyn, Bart., F.Z.S. Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S., F.R.S.E., Pres.G.S. Sir Robert Ball, LL.D., F.R.S., F.R.A.S., Royal Astronomer of Ireland	R. W. Atkinson, Esq., B.Sc., F.C.S., F.I.C. Professor H. W. Lloyd Tanner, M.A., F.R.A.S.
SIR ARCHIBALD GEIKIE, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom. EDINBURGH, August 3, 1892	The Right Hon. the Lord Provost of Edinburgh The Most Hon. the Marquess of Lothian, K.T. The Right Hon. the Earl of Rosebery, LL.D., F.R.S., F.R.S.E. The Right Hon. J. H. A. Macdonald, C.B., LL.D., F.R.S., F.R.S.E. Principal Sir William Muir, K.C.S.I., D.C.L. Professor Sir Douglas Maclagan, M.D., Pres.R.S.E. Professor Sir William Turner, F.R.S., F.R.S.E. Professor P. G. Tait, M.A., F.R.S.E. Professor A. Crum Brown, M.D., F.R.S., F.R.S.E., Pres.C.S.	Professor G. F. Armstrong, M.A., M.Inst.C.E., F.R.S.E., F.G.S. F. Grant Ogilvie, Esq., M.A., B.Sc., F.R.S.E. John Harrison, Esq.

DR. J. S. BURDON SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford. NOTTINGHAM, September 13, 1893.	His Grace the Duke of St. Albans, Lord-Lieut. of Nottinghamshire His Grace the Duke of Devonshire, K.G., Chancellor of the University of Cambridge His Grace the Duke of Portland. His Grace the Duke of Newcastle The Right Hon. Lord Belper. The Mayor of Nottingham The Right Hon. Sir W. R. Grove, M.A., D.C.L., LL.D., F.R.S., F.R.S.E. Sir John Turney, J.P. Professor Michael Foster, M.A., Sec.R.S. W. H. Ransom, Esq., M.D., F.R.S.	Professor F. Clowes, D.Sc. Professor W. H. Heaton, M.A. Arthur Williams, Esq.
The MOST HON. THE MARQUIS OF SALISBURY, K.G., D.C.L., F.R.S., Chancellor of the University of Oxford. OXFORD, August 8, 1894.	The Right Hon. the Earl of Jersey, G.C.M.G., Lord-Lieutenant of the County of Oxford The Right Hon. Lord Wantage, K.C.B., V.C., Lord-Lieutenant of Berkshire The Right Hon. the Earl of Rosebery, K.G., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Oxford, D.D. The Right Hon. Lord Rothschild, Lord-Lieutenant of Buckinghamshire. The Right Hon. Lord Kelvin, D.C.L., Pres.R.S. The Rev. the Vice-Chancellor of the University of Oxford. The Mayor of Oxford. Sir W. R. Anson, D.C.L., Warden of All Souls College. Sir Bernhard Samuelson, Bart., M.P., F.R.S. Sir Henry Dyke Acland, Bart., M.D., F.R.S., Regius Professor of Medicine. The Rev. the Master of Pembroke College, Sedleian Professor of Natural Philosophy. Dr. J. J. Sylvester, F.R.S., Savilian Professor of Geometry.	Gilbert C. Bourne, Esq., M.A. G. C. Druce, Esq., M.A. D. H. Nagel, Esq., M.A.
CAPTAIN SIR DOUGLAS GALTON, K.C.B., D.C.L., LL.D., F.R.S., F.R.G.S., F.G.S. IPSWICH, September 11, 1895	The Most Hon. the Marquis of Bristol, M.A., Lord.-Lieutenant of the County of Suffolk The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge The Right Hon. Lord Rayleigh, D.C.L., Sec.R.S., Lord-Lieutenant of the County of Essex The Right Hon. Lord Gwydyr, M.A., High Steward of the Borough of Ipswich The Right Hon. Lord Henniker, F.S.A. The Right Hon. Lord Rendlesham. J. H. Bartlet, Esq., Mayor of Ipswich Sir G. G. Stokes, Bart., D.C.L., F.R.S. Dr. E. Frankland, D.C.L., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S. Felix T. Cobbold, Esq., M.A.	G. H. Hewetson, Esq. S. A. Notcutt, Esq., B.A., LL.M., B.Sc. E. P. Ridley, Esq.

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1872–76 Capt. DOUGLAS GALTON, F.R.S., and Dr. MICHAEL FOSTER, F.R.S.
1876–81 Capt. DOUGLAS GALTON, F.R.S., and Dr. P. L. SCLATER, F.R.S.
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1883–95 Sir DOUGLAS GALTON, F.R.S., and A. G. VERNON HARCOURT, Esq., F.R.S.
1895–96 A. G. VERNON HARCOURT, Esq., F.R.S., and Prof. E. A. SCHÄFER, F.R.S.

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1890 G. GRIFFITH, Esq., M.A., *Acting Secretary.*
1890–95 G. GRIFFITH, Esq., M.A.

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Date and Place	Presidents	Secretaries

MATHEMATICAL AND PHYSICAL SCIENCES.

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1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.

SECTION A.—MATHEMATICS AND PHYSICS.

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1851. Ipswich ...	Rev. W. Whewell, D.D., F.R.S.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast......	Prof. W. Thomson, M.A., F.R.S., F.R.S.E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull.........	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.

Date and Place	Presidents	Secretaries
1854. Liverpool...	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow ...	Rev. Prof. Kelland, M.A., F.R.S., F.R.S.E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin......	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen...	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.
1860. Oxford......	Rev. B. Price, M.A., F.R.S....	Rev. G. C. Bell, Rev. T. Rennison, Prof. Stevelly.
1861. Manchester	G. B. Airy, M.A., D.C.L., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1862. Cambridge	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath.........	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee ...	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter......	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford...	Prof. H. J. S. Smith, F.R.S. .	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast......	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol......	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin......	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.

Date and Place	Presidents	Secretaries
1880. Swansea ...	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1881. York.........	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	Prof. W. E. Ayrton, Dr. O. J. Lodge, D. MacAlister, Rev. W. Routh.
1882. Southampton.	Rt. Hon. Prof. Lord Rayleigh, M.A., F.R.S.	W. M. Hicks, Dr. O. J. Lodge, D. MacAlister, Rev. G. Richardson.
1883. Southport	Prof. O. Henrici, Ph.D., F.R.S.	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Prof. R. C. Rowe.
1884. Montreal ...	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	C. Carpmael, W. M. Hicks, A. Johnson, O. J. Lodge, D. MacAlister.
1885. Aberdeen...	Prof. G. Chrystal, M.A., F.R.S.E.	R. E. Baynes, R. T. Glazebrook, Prof. W. M. Hicks, Prof. W. Ingram.
1886. Birmingham	Prof. G. H. Darwin, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. J. H. Poynting, W. N. Shaw.
1887. Manchester	Prof. Sir R. S. Ball, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. H. Lamb, W. N. Shaw.
1888. Bath.........	Prof. G. F. Fitzgerald, M.A., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw.
1889. Newcastle-upon-Tyne	Capt. W. de W. Abney, C.B., R.E., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw, H. Stroud.
1890. Leeds	J. W. L. Glaisher, Sc.D., F.R.S., V.P.R.A.S.	R. T. Glazebrook, Prof. A. Lodge, W. N. Shaw, Prof. W. Stroud.
1891. Cardiff......	Prof. O. J. Lodge, D.Sc., LL.D., F.R.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Prof. A. L. Selby.
1892. Edinburgh	Prof. A. Schuster, Ph.D., F.R.S., F.R.A.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1893. Nottingham	R. T. Glazebrook, M.A., F.R.S.	W. T. A. Emtage, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1894. Oxford......	Prof. A. W. Rücker, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, J. Walker.
1895. Ipswich ...	Prof. W. M. Hicks, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge G. T. Walker, W. Watson.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY.

1832. Oxford......	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope...........................	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

1835. Dublin......	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol......	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.......	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, Robert Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.........	Prof. Apjohn, M.R.I.A.........	R. Hunt, Dr. Sweeny.
1844. York.........	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.

Date and Place	Presidents	Secretaries
1846. Southampton.	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford......	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.......	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E.	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast......	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin......	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford......	Prof. B. C. Brodie, F.R.S......	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. H. Miller, M.A., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.........	W. Odling, M.B., F.R.S.	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S.	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. T. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast......	Prof. A. Crum Brown, M.D., F.R.S.E.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S...............	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.

Date and Place	Presidents	Secretaries
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S.	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. Phillips Bedson, H. B. Dixon, Dr. W. R. Eaton Hodgkinson, J. M. Thomson.
1881. York.........	Prof. A. W. Williamson, F.R.S.	P. P. Bedson, H. B. Dixon, T. Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E. Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen ...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, W. W. J. Nicol, C. J. Woodward.
1887. Manchester	Dr. E. Schunck, F.R.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.........	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, H. Forster Morley, R. E. Moyle, W W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S.	H. Forster Morley, D. H. Nagel, W. W. J. Nicol, H. L. Pattinson, jun.
1890. Leeds	Prof. T. E. Thorpe, B.Sc., Ph.D., F.R.S., Treas. C.S.	C. H. Bothamley, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1891. Cardiff	Prof. W. C. Roberts-Austen, C.B., F.R.S.	C. H. Bothamley, H. Forster Morley, W. W. J. Nicol, G. S. Turpin.
1892. Edinburgh	Prof. H. McLeod, F.R.S.	J. Gibson, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1893. Nottingham	Prof. J. Emerson Reynolds, M.D., D.Sc., F.R.S.	J. B. Coleman, M. J. R. Dunstan, D. H. Nagel, W. W. J. Nicol.
1894. Oxford......	Prof. H. B. Dixon, M.A., F.R.S.	A. Colefax, W. W. Fisher, Arthur Harden, H. Forster Morley.

SECTION B (*continued*).—CHEMISTRY.

1895. Ipswich ...	Prof. R. Meldola, F.R.S.	E. H. Fison, Arthur Harden, C. A. Kohn, J. W. Rodger.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge.	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh.	Prof. Jameson	J. Phillips, T. J. Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geog.*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool...	Rev. Prof. Sedgwick, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Capt. H. M. Denham, R.N.
1838. Newcastle...	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.

Date and Place	Presidents	Secretaries
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, Hugh Murray, H. E. Strickland, John Scoular, M.D.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork.........	Richard E. Griffith, F.R.S., M.R.I.A.	Francis M. Jennings, H. E. Strickland.
1844. York.........	Henry Warburton, M.P., Pres. Geol. Soc.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge.	Rev. Prof. Sedgwick, M.A., F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.—*Geography*, G. B. Greenough, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham.—*Geography*, Dr. C. T. Beke.
1847. Oxford......	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, C.B., F.R.S.	Starling Benson, Prof. Oldham, Prof. Ramsay.
1849. Birmingham	Sir Charles Lyell, F.R.S., F.G.S.	J. Beete Jukes, Prof. Oldham, Prof. A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

SECTION C (*continued*).—GEOLOGY.

1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.........	Prof. Harkness, William Lawton.
1854. Liverpool..	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	James Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, Gilbert Sanders, Robert H. Scott.
1858. Leeds	William Hopkins, M.A., LL.D., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, LL.D., F.R.S., F.G.S.	Prof. Harkness, Edward Hull, Capt. D. C. L. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.

[1] At a meeting of the General Committee held in 1850, it was resolved 'That the subject of Geography be separated from Geology and combined with Ethnology, to constitute a separate Section, under the title of the "Geographical and Ethnological Section," for Presidents and Secretaries of which see page lxii.

Date and Place	Presidents	Secretaries
1864. Bath.........	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S., F.G.S.	Edward Hull, W. Pengelly, Henry Woodward.
1868. Norwich ...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool...	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton...	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford...	Prof. J. Phillips, D.C.L., F.R.S., F.G.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast......	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol......	Dr. T. Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow ...	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth...	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin......	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield ...	Prof. P. M. Duncan, F.R.S.	W. Topley, G. Blake Walker.
1880. Swansea ...	H. C. Sorby, F.R.S., F.G.S....	W. Topley, W. Whitaker.
1881. York.........	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal ...	W. T. Blanford, F.R.S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen ...	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.
1888. Bath.........	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.
1890. Leeds	Prof. A. H. Green, M.A., F.R.S., F.G.S.	J. E. Bedford, Dr. F. H. Hatch, J. E. Marr, W. W. Watts.
1891. Cardiff......	Prof. T. Rupert Jones, F.R.S., F.G.S.	W. Galloway, J. E. Marr, Clement Reid, W. W. Watts.
1892. Edinburgh	Prof. C. Lapworth, LL.D., F.R.S., F.G.S.	H. M. Cadell, J. E. Marr, Clement Reid, W. W. Watts.
1893. Nottingham	J. J. H. Teall, M.A., F.R.S., F.G.S.	J. W. Carr, J. E. Marr, Clement Reid, W. W. Watts.
1894. Oxford......	L. Fletcher, M.A., F.R.S.	F. A. Bather, A. Harker, Clemen Reid, W. W. Watts.
1895. Ipswich ...	W. Whitaker, B.A., F.R.S. ...	F. A. Bather, G. W. Lamplugh, H A. Miers, Clement Reid.

Date and Place	Presidents	Secretaries

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

1832. Oxford......	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh.	Prof. Graham.....................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

1835. Dublin......	Dr. Allman........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay..................	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.......	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.........	William Thompson, F.L.S. ...	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.........	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lxi.]

1848. Swansea ...	L. W. Dillwyn, F.R.S..........	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S. L. & E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich ...	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast......	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull.........	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool...	Prof. Balfour, M.D., F.R.S....	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow ...	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres.L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. Lankester.
1857. Dublin......	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.

[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. lxi.

Date and Place	Presidents	Secretaries
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen...	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford......	Rev. Prof. Henslow, F.L.S....	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D.. F.R.S....	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath.........	Dr. John E. Gray, F.R.S. ...	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham	T. Thomson, M.D., F.R.S. ...	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.[1]

1866. Nottingham	Prof. Huxley, LL.D., F.R.S. —*Physiological Dep.*, Prof. Humphry, M.D., F.R.S.—*Anthropological Dep.*, Alf. R. Wallace, F.R.G.S.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee ...	Prof. Sharpey, M.D., Sec. R.S. —*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich ...	Rev. M. J. Berkeley, F.L.S. —*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter	George Busk, F.R.S., F.L.S. —*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.—*Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.
1870. Liverpool...	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.
1871. Edinburgh.	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.

[1] At a meeting of the General Committee in 1865, it was resolved 'That the title of Section D be changed to Biology;' and 'That for the word "Subsection," in the rules for conducting the business of the Sections, the word "Department" be substituted.'

Date and Place	Presidents	Secretaries
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres.R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Cleland, M.D., F.R.S.—*Dep. of Anthropol.*, Prof. Rolleston, M.D., F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.R.G.S., F.L.S.—*Dep. of Zool. and Bot.*, Prof. A. Newton, M.A., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick, F.R.S.E.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, LL.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. Macalister, M.D.—*Dep. of Anthropol.*, Francis Galton, M.A., F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.—*Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S. —*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, M.D., F.R.S. —*Dep. of Anat. and Physiol.*, F. M. Balfour, M.A., F.R.S.—*Dep. of Anthropol.*, F. W. Rudler, F.G.S.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York.........	Richard Owen, C.B., M.D., F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, LL.D., F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, M.D., F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M'Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.
1882. Southampton.[1]	Prof. A. Gamgee, M.D., F.R.S. —*Dep. of Zool. and Bot.*, Prof. M. A. Lawson, M.A., F.L.S.—*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, M.A., F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport[2]	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.
1884. Montreal ...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen ...	Prof. W. C. McIntosh, M.D., LL.D., F.R.S. F.R.S.E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.

[1] The Departments of Zoology and Botany and of Anatomy and Physiology were amalgamated.

[2] Anthropology was made a separate Section, see p. lxviii.

Date and Place	Presidents	Secretaries
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.
1887. Manchester	Prof. A. Newton, M.A., F.R.S., F.L.S., V.P.Z.S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath	W. T. Thiselton-Dyer, C.M.G., F.R.S., F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner, Prof. W. D. Halliburton.
1889. Newcastle-upon-Tyne	Prof. J. S. Burdon Sanderson, M.A., M.D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.
1890. Leeds	Prof. A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S.	S. F. Harmer, Prof. W. A. Herdman, Dr. S. J. Hickson, Prof. F. W. Oliver, H. Wager, Prof. H. Marshall Ward.
1891. Cardiff	Francis Darwin, M.A., M.B., F.R.S., F.L.S.	F. E. Beddard, Prof. W. A. Herdman, Dr. S. J. Hickson, G. Murray, Prof. W. N. Parker, H. Wager.
1892. Edinburgh	Prof. W. Rutherford, M.D., F.R.S., F.R.S.E.	G. Brook, Prof. W. A. Herdman, G. Murray, W. Stirling, H. Wager.
1893. Nottingham[1]	Rev. Canon H. B. Tristram, M.A., LL.D., F.R.S.	G. C. Bourne, J. B. Farmer, Prof. W. A. Herdman, S. J. Hickson, W. B. Ransom, W. L. Sclater.
1894. Oxford[2] ...	Prof. I. Bayley Balfour, M.A., F.R.S.	W. W. Benham, Prof. J. B. Farmer, Prof. W A. Herdman, Prof. S. J. Hickson, G. Murray, W. L. Sclater.

SECTION D (*continued*).—ZOOLOGY.

1895. Ipswich ...	Prof. W. A. Herdman, F.R.S.	G. C. Bourne, H. Brown, W. E. Hoyle, W. L. Sclater.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. J. Haviland	Dr. H. J. H. Bond, Mr. G. E. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. J. C. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. P. M. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool...	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S....	Dr. G. O. Rees, F. Ryland.
1840. Glasgow ...	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof. Reid.

SECTION E.—PHYSIOLOGY.

1841. Plymouth ...	P. M. Roget, M.D., Sec. R.S.	Dr. J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D. ...	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.

[1] Physiology was made a separate Section, see p. lxviii.

[2] The title of Section D was changed to Zoology.

Date and Place	Presidents	Secretaries
1846. Southampton.	Prof. Owen, M.D., F.R.S. ...	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1] ...	Prof. Ogle, M.D., F.R.S.	Dr. Thomas K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUBSECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow ...	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin......	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir Benjamin Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen...	Prof. Sharpey, M.D., Sec.R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford......	Prof.G.Rolleston,M.D.,F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S. L. & E.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	G. E. Paget, M.D...............	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath.........	Dr. Edward Smith, LL.D., F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham.[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. lv.]

ETHNOLOGICAL SUBSECTIONS OF SECTION D.

1846. Southampton	Dr. J. C. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A. ...	Prof. Buckley.
1848. Swansea ...	....	G. Grant Francis.
1849. Birmingham	....	Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

1851. Ipswich ...	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast......	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, R. MacAdam, Dr. Norton Shaw.
1853. Hull.........	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool...	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow ...	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin......	Rev. Dr. J. Henthorn Todd, Pres. R.I.A.	R. Cull, S. Ferguson, Dr. R. R. Madden, Dr. Norton Shaw.

[1] By direction of the General Committee at Oxford, Sections D and E were incorporated under the name of 'Section D—Zoology and Botany, including Physiology' (see p. lviii.). Section E, being then vacant, was assigned in 1851 to Geography.

[2] *Vide* note on page lix.

Date and Place	Presidents	Secretaries
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, Francis Galton, P. O'Callaghan, Dr. Norton Shaw, Thomas Wright.
1859. Aberdeen...	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford......	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S..........	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S..........	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath.........	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee ...	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, Clements R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich ...	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

Date and Place	Presidents	Secretaries
1869. Exeter......	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool...	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas.
1872. Brighton ...	Francis Galton, F.R.S..........	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast......	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol......	Lieut.-General Strachey, R.E., C.S.I., F.R.S., F.R.G.S., F.L.S., F.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.......	H. W. Bates, E. C. Rye, R. Oliphant Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B., F.R.S., F.R.G.S., F.R.A.S.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin......	Prof. Sir C. Wyville Thomson, LL.D., F.R.S., F.R.S.E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea ...	Lieut.-Gen. Sir J. H. Lefroy, C.B., K.C.M.G., R.A., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye.
1881. York.........	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye
1883. Southport	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.

Date and Place	Presidents	Secretaries
1884. Montreal ...	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R.G.S.	Rev. Abbé Laflamme, J. S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen...	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham	Maj.-Gen. Sir. F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie, E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1888. Bath.........	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.
1890. Leeds	Lieut.-Col. Sir R. Lambert Playfair, K.C.M.G., F.R.G.S.	A. Barker, John Coles, J. S. Keltie, A. Silva White.
1891. Cardiff......	E. G. Ravenstein, F.R.G.S., F.S.S.	John Coles, J. S. Keltie, H. J. Mackinder, A. Silva White, Dr. Yeats.
1892. Edinburgh	Prof. J. Geikie, D.C.L., F.R.S., V.P.R.Scot.G.S.	J. G. Bartholomew, John Coles, J. S. Keltie, A. Silva White.
1893. Nottingham	H. Seebohm, Sec. R.S., F.L.S., F.Z.S.	Col. F. Bailey, John Coles, H. O. Forbes, Dr. H. R. Mill.
1894. Oxford......	Capt. W. J. L. Wharton, R.N., F.R.S.	John Coles, W. S. Dalgleish, H. N. Dickson, Dr. H. R. Mill.
1895. Ipswich ...	H. J. Mackinder, M.A., F.R.G.S.	John Coles, H. N. Dickson, Dr. H. R. Mill, W. A. Taylor.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.......	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol......	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool...	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham	Henry Hallam, F.R.S..........	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow ...	Rt. Hon. Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth...	Lieut.-Col. Sykes, F.R.S.......	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S. ...	Rev. R. Luney, G. W. Ormerod, Dr. W. C. Tayler.
1843. Cork.........	Sir C. Lemon, Bart., M.P. ...	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York.........	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford......	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea ...	J. H. Vivian, M.P., F.R.S. ...	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham	Rt. Hon. Lord Lyttelton......	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.

Date and Place	Presidents	Secretaries
1851. Ipswich ...	Sir John P. Boileau, Bart. ...	J. Fletcher, Prof. Hancock.
1852. Belfast......	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.
1853. Hull.........	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Walsh.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin......	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford......	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle .	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath.........	William Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers...........	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant-Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872. Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast......	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres. S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin......	Prof. J. K. Ingram, LL.D., M.R.I.A.	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York.........	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.

Date and Place	Presidents	Secretaries
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal ...	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen...	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.
1886. Birmingham	J. B. Martin, M.A., F.S.S.	F. F. Barham, Rev. W. Cunningham, Prof. H. S. Foxwell, J. F. Moss.
1887. Manchester	Robert Giffen, LL.D.,V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, J. E. C. Munro, G. H. Sargant.
1888. Bath.........	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.
1890. Leeds	Prof. A. Marshall, M.A., F.S.S.	W. A. Brigg, Rev. Dr. Cunningham, T. H. Elliott, Prof. J. E. C. Munro, L. L. F. R. Price.
1891. Cardiff......	Prof. W. Cunningham, D.D., D.Sc., F.S.S.	Prof. J. Brough, E. Cannan, Prof. E. C. K. Gonner, H. Ll. Smith, Prof. W. R. Sorley.
1892. Edinburgh	Hon. Sir C. W. Fremantle, K.C.B.	Prof. J. Brough, J. R. Findlay, Prof. E. C. K. Gonner, H. Higgs, L. L. F. R. Price.
1893. Nottingham	Prof. J. S. Nicholson, D.Sc., F.S.S.	Prof. E. C. K. Gonner, H. de B. Gibbins, J. A. H. Green, H. Higgs, L. L. F. R. Price.
1894. Oxford......	Prof. C. F. Bastable, M.A., F.S.S.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1895. Ipswich ...	L. L. Price, M.A.	E. Cannan, Prof. E. C. K. Gonner, H. Higgs.

MECHANICAL SCIENCE.

SECTION G.—MECHANICAL SCIENCE.

1836. Bristol......	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.......	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork.........	Prof. J. Macneill, M.R.I.A....	James Thomson, Robert Mallet.
1844. York.........	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S..........	Rev. W. T. Kingsley.
1846. South'mpt'n	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford......	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingh'm	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich	William Cubitt, F.R.S..	John Head, Charles Manby

Date and Place	Presidents	Secretaries
1852. Belfast......	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, C.E., F.R.S.	James Oldham, J. Thomson, W. Sykes Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	J. Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. Macquorn Rankine, F.R.S.	L. Hill, W. Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, H. M. Jeffery.
1857. Dublin......	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson H. Wright.
1862. Cambridge	William Fairbairn, F.R.S.	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer.
1864. Bath	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P. Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee......	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S.........	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, Alexander Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	Crawford Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred.
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow ...	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth...	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield ...	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea ...	James Abernethy, V.P. Inst. C.E., F.R.S.E.	A. T. Atchison, H. T. Wood.
1881. York.........	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton	John Fowler, C.E., F.G.S. ...	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport	J. Brunlees, Pres. Inst. C.E.	A. T. Atchison, E. Rigg, H. T. Wood.
1884. Montreal ...	Sir F. J. Bramwell, F.R.S., V.P.Inst.C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.

Date and Place	Presidents	Secretaries
1885. Aberdeen...	B. Baker, M.Inst.C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886. Birmingham	Sir J. N. Douglass, M.Inst. C.E.	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
1887. Manchester	Prof. Osborne Reynolds, M.A., LL.D., F.R.S.	C. F. Budenberg, W. B. Marshall, E. Rigg.
1888. Bath.........	W. H. Preece, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, E. Rigg, P. K. Stothert.
1889. Newcastle-upon-Tyne	W. Anderson, M.Inst.C.E. ...	C. W. Cooke, W. B. Marshall, Hon. C. A. Parsons, E. Rigg.
1890. Leeds	Capt. A. Noble, C.B., F.R.S., F.R.A.S.	E. K. Clark, C. W. Cooke, W. B. Marshall, E. Rigg.
1891. Cardiff......	T. Forster Brown, M.Inst.C.E.,	C. W. Cooke, Prof. A. C. Elliott, W. B. Marshall, E. Rigg.
1892. Edinburgh	Prof. W. C. Unwin, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, W. C. Popplewell, E. Rigg.
1893. Nottingham	Jeremiah Head, M.Inst.C.E., F.C.S.	C. W. Cooke, W. B. Marshall, E. Rigg, H. Talbot.
1894. Oxford......	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, Rev. F. J. Smith.
1895. Ipswich ...	Prof. L. F. Vernon-Harcourt, M.A., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, P. G. M. Stoney.

SECTION H.—ANTHROPOLOGY.

1884. Montreal...	E. B. Tylor, D.C.L., F.R.S. ...	G. W. Bloxam, W. Hurst.
1885. Aberdeen...	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. A. Macgregor.
1886. Birmingham	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby.
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson.
1888. Bath.........	Lieut.-General Pitt-Rivers, D.C.L., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.
1890. Leeds	Dr. J. Evans, Treas. R.S., F.S.A., F.L.S., F.G.S.	G. W. Bloxam, Dr. C. M. Chadwick, Dr. J. G. Garson.
1891. Cardiff......	Prof. F. Max Müller, M.A. ...	G. W. Bloxam, Prof. R. Howden, H. Ling Roth, E. Seward.
1892. Edinburgh	Prof. A. Macalister, M.A., M.D., F.R.S.	G. W. Bloxam, Dr. D. Hepburn, Prof. R. Howden, H. Ling Roth.
1893. Nottingham	Dr. R. Munro, M.A., F.R.S.E.	G. W. Bloxam, Rev. T. W. Davies, Prof. R. Howden, F. B. Jevons, J. L. Myres.
1894. Oxford......	Sir W. H. Flower, K.C.B., F.R.S.	H. Balfour, Dr. J. G. Garson, H. Ling Roth.
1895. Ipswich ...	Prof. W. M. Flinders Petrie, D.C.L.	J. L. Myres, Rev. J. J. Raven, H. Ling Roth.

SECTION I.—PHYSIOLOGY (including Experimental Pathology and Experimental Psychology).

1894. Oxford......	Prof. E. A. Schäfer, F.R.S., M.R.C.S.	Prof F. Gotch, Dr. J. S. Haldane, M. S. Pembrey.

SECTION K.—BOTANY.

1895. Ipswich ...	W. T. Thiselton-Dyer, F.R.S.	Prof. F. E. Weiss, A. C. Seward.

LIST OF EVENING LECTURES.

Date and Place	Lecturer	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S.	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S.	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G.B.Airy,F.R.S.,Astron.Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S.	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S.	Properties of the Explosive Substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.
1847. Oxford	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S.	The Dodo (*Didus ineptus*).
1848. Swansea	John Percy, M.D., F.R.S.	Metallurgical Operations of Swansea and its Neighbourhood.
	W. Carpenter, M.D., F.R.S.	Recent Microscopical Discoveries.
1849. Birmingham	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying Velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their changes of Form.
	G.B.Airy,F.R.S.,Astron. Royal	Total Solar Eclipse of July 28, 1851.
1852. Belfast	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent Discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent Discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.	The present state of Photography.
1854. Liverpool	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of Researches in Terrestrial Magnetism.
1855. Glasgow	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform Research up to the present time.
	W. R. Grove, F.R.S.	Correlation of Physical Forces.

Date and Place	Lecturer	Subject of Discourse
1857 Dublin......	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford......	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal.	The late Eclipse of the Sun.
1862 Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.............	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.......	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.........	The Balloon Ascents made for the British Association.
1864. Bath.........	Prof. Roscoe, F.R.S............	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.
1865. Birmingham	J. Beete Jukes, F.R.S.........	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S.......	The results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.......	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S.......	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of Knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S............	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S. ...	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S...............	Some Recent Investigations and Applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilisation.
1872. Brighton ...	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarised Light.
	F. J. Bramwell, F.R.S.........	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The *Challenger* Expedition.

Date and Place	Lecturer	Subject of Discourse
1877. Plymouth...	W. Warington Smyth, M.A., F.R.S.	The Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.	The New Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield ...	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.
1880. Swansea ...	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S..........	Mental Imagery.
1881. York.........	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S....	The Electric Discharge, its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick, F.R.S.E.	Galvanic and Animal Electricity.
1884. Montreal...	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen...	Prof. W. G. Adams, F.R.S. ...	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E.........	The Great Ocean Basins.
1886. Birmingham	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D. ...	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S. ...	The Rate of Explosions in Gases.
	Col. Sir F. de Winton, K.C.M.G.	Explorations in Central Africa.
1888. Bath.........	Prof. W. E. Ayrton, F.R.S. ...	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.........	How Plants maintain themselves in the Struggle for Existence.
1890. Leeds	E. B. Poulton, M.A., F.R.S....	Mimicry.
	Prof. C. Vernon Boys, F.R.S.	Quartz Fibres and their Applications.
1891. Cardiff	Prof. L. C. Miall, F.L.S., F.G.S.	Some Difficulties in the Life of Aquatic Insects.
	Prof. A. W. Rücker, M.A., F.R.S.	Electrical Stress.
1892. Edinburgh	Prof. A. Milnes Marshall, D.Sc., F.R.S.	Pedigrees.
	Prof. J. A. Ewing, M.A., F.R.S., F.R.S.E.	Magnetic Induction.
1893. Nottingham	Prof. A. Smithells, B.Sc.	Flame.
	Prof. Victor Horsley, F.R.S.	The Discovery of the Physiology of the Nervous System.
1894. Oxford......	J. W. Gregory, D.Sc., F.G.S.	Experiences and Prospects of African Exploration.
	Prof. J. Shield Nicholson, M.A.	Historical Progress and Ideal Socialism.
1895. Ipswich ...	Prof. S. P. Thompson, F.R.S.,	Magnetism in Rotation.
	Prof. Percy F. Frankland, F.R.S.	The Work of Pasteur and its various Developments.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturer	Subject of Discourse
1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	Experimental Illustrations of the modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool....	Sir John Lubbock, Bart., M.P., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S............	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B., R.N.	A Journey through Africa.
1877. Plymouth...	W. H. Preece	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power.
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	John Evans, D.C.L., Treas. R.S.	Unwritten History, and how to read it.
1883. Southport	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S.........	Comets.
1885. Aberdeen ...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath	Sir John Lubbock, Bart., M.P., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.
1890. Leeds	Prof. J. Perry, D.Sc., F.R.S.	Spinning Tops.
1891. Cardiff	Prof. S. P. Thompson, F.R.S.	Electricity in Mining.
1892. Edinburgh	Prof. C. Vernon Boys, F.R.S.	Electric Spark Photographs.
1893. Nottingham	Prof. Vivian B. Lewes	Spontaneous Combustion.
1894. Oxford	Prof. W. J. Sollas, F.R.S. ...	Geologies and Deluges.
1895. Ipswich ...	Dr. A. H. Fison	Colour.

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1894-95. RECEIPTS.

				£	s.	d.
Balance brought forward				1094	2	6
Life Compositions				310	0	0
New Annual Members' Subscriptions				190	0	0
Annual Subscriptions				654	0	0
Sale of Associates' Tickets				915	0	0
Sale of Ladies' Tickets				449	0	0
Sale of Index, 1861–90	£38	9	3			
Sale of other Publications	174	3	1			
				212	12	4
Interest on Deposit at Oxford Bank				7	14	7
Interest on Exchequer Bills				11	9	8
Dividends on Consols				206	15	4
Dividends on India 3 per Cents.				104	8	0
Unexpended Balance of Grant for exploring the Lake Village at Glastonbury	£5	0	2			
Unexpended Balance of Grant from the Erratic Blocks Committee	3	18	0			
Unexpended Grant from the Committee for making Observations in South Georgia	50	0	0			
				58	18	2
				£4214	0	7

Investments

		£	s.	d.
June 30, 1894:	Consols	7537	3	5
	India 3 per Cents.	3600	0	0
		£11137	3	5

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1894–95. PAYMENTS.	£	s.	d.
Expenses of Oxford Meeting, including Printing, Advertising, Payment of Clerks, &c.	166	1	1
Rent and Office Expenses	48	13	5
Commission on Purchase of Exchequer Bills	2	15	6
Compilation of Index 1861–90	100	0	0
Salaries	505	0	0
Printing, Binding, &c.	791	15	3
Payment of Grants made at Oxford:			

	£	s.	d.
Electrical Standards	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Earth Tremors	75	0	0
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Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
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Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives	30	0	0
Electrolytic Quantitative Analysis	30	0	0
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Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut	50	0	0
Calibration and Comparison of Measuring Instruments	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph	25	0	0
Corresponding Societies	30	0	0
	977	15	5

In hands of General Treasurer:

	£	s.	d.	£	s.	d.	£	s.	d.
At Bank of England, Western Branch	£683	12	5						
Less Cheques not presented	63	0	0						
				620	12	5			
Exchequer Bills				1000	0	0			
Cash				1	7	6			
							1621	19	11
							£4214	0	7

Account.

		£	s.	d.
June 29, 1895:	Consols	7537	3	5
	India 3 per Cents.	3600	0	0
		£11,137	3	5

ARTHUR W. RÜCKER, *General Treasurer.*

July 9, 1895.

Table showing the Attendance and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27	York	The Earl Fitzwilliam, D.C.L.	—	—
1832, June 19	Oxford	The Rev. W. Buckland, F.R.S.	—	—
1833, June 25	Cambridge	The Rev. A. Sedgwick, F.R.S.	—	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, D.C.L.	—	—
1835, Aug. 10	Dublin	The Rev. Provost Lloyd, LL.D.	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne	—	—
1837, Sept. 11	Liverpool	The Earl of Burlington, F.R.S.	—	—
1838, Aug. 10	Newcastle-on-Tyne	The Duke of Northumberland	—	—
1839, Aug. 26	Birmingham	The Rev. W. Vernon Harcourt	—	—
1840, Sept. 17	Glasgow	The Marquis of Breadalbane	—	—
1841, July 20	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23	Manchester	The Lord Francis Egerton	303	169
1843, Aug. 17	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26	York	The Rev. G. Peacock, DD.	226	150
1845, June 19	Cambridge	Sir John F. W. Herschel, Bart.	313	36
1846, Sept. 10	Southampton	Sir Roderick I. Murchison, Bart.	241	10
1847, June 23	Oxford	Sir Robert H. Inglis, Bart.	314	18
1848, Aug. 9	Swansea	The Marquis of Northampton	149	3
1849, Sept. 12	Birmingham	The Rev. T. R. Robinson, D.D.	227	12
1850, July 21	Edinburgh	Sir David Brewster, K.H.	235	9
1851, July 2	Ipswich	G. B. Airy, Astronomer Royal	172	8
1852, Sept. 1	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6	Cheltenham	Prof. C. G. B. Daubeny, M.D.	182	14
1857, Aug. 26	Dublin	The Rev. Humphrey Lloyd, D.D.	236	15
1858, Sept. 22	Leeds	Richard Owen, M.D., D.C.L.	222	42
1859, Sept. 14	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27	Oxford	The Lord Wrottesley, M.A.	286	21
1861, Sept. 4	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1	Cambridge	The Rev. Professor Willis, M.A.	239	15
1863, Aug. 26	Newcastle-on-Tyne	Sir William G. Armstrong, C.B.	203	36
1864, Sept. 13	Bath	Sir Charles Lyell, Bart., M.A.	287	40
1865, Sept. 6	Birmingham	Prof. J. Phillips, M.A., LL.D.	292	44
1866, Aug. 22	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4	Dundee	The Duke of Buccleuch, K.C.B.	167	25
1868, Aug. 19	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18	Exeter	Prof. G. G. Stokes, D.C.L.	204	21
1870, Sept. 14	Liverpool	Prof. T. H. Huxley, LL.D.	314	39
1871, Aug. 2	Edinburgh	Prof. Sir W. Thomson, LL.D.	246	28
1872, Aug. 14	Brighton	Dr. W. B. Carpenter, F.R.S.	245	36
1873, Sept. 17	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25	Bristol	Sir John Hawkshaw, C.E., F.R.S.	239	36
1876, Sept. 6	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25	Swansea	A. C. Ramsay, LL.D., F.R.S.	144	11
1881, Aug. 31	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23	Southampton	Dr. C. W. Siemens F.R.S.	178	17
1883, Sept. 19	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, F.R.S.	235	20
1885, Sept. 9	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1	Birmingham	Sir J. W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5	Bath	Sir F. J. Bramwell, F.R.S.	266	36
1889, Sept. 11	Newcastle-on-Tyne	Prof. W. H. Flower, C.B., F.R.S.	277	20
1890, Sept. 3	Leeds	Sir F. A. Abel, C.B., F.R.S.	259	21
1891, Aug. 19	Cardiff	Dr. W. Huggins, F.R.S.	189	24
1892, Aug. 3	Edinburgh	Sir A. Geikie, LL.D., F.R.S.	280	14
1893, Sept. 13	Nottingham	Prof. J. S. Burdon Sanderson	201	17
1894, Aug. 8	Oxford	The Marquis of Salisbury, K.G., F.R.S.	327	21
1895, Sept. 11	Ipswich	Sir Douglas Galton, F.R.S.	214	13

* Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.

at Annual Meetings of the Association.

Attended by						Amount received during the Meeting	Sums paid on Account of Grants for Scientific Purposes	Year
Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total			
—	—	—	—	—	353	—	—	1831
—	—	—	—	—	—	—	—	1832
—	—	—	—	—	900	—	—	1833
—	—	—	—	—	1298	—	£20 0 0	1834
—	—	—	—	—	—	—	167 0 0	1835
—	—	—	—	—	1350	—	435 0 0	1836
—	—	—	—	—	1840	—	922 12 6	1837
—	—	—	1100*	—	2400	—	932 2 2	1838
—	—	—	—	34	1438	—	1595 11 0	1839
—	—	—	—	40	1353	—	1546 16 4	1840
46	317	—	60*	—	891	—	1235 10 11	1841
75	376	33†	331*	28	1315	—	1449 17 8	1842
71	185	—	160	—	—	—	1565 10 2	1843
45	190	9†	260	—	—	—	981 12 8	1844
94	22	407	172	35	1079	—	831 9 9	1845
65	39	270	196	36	857	—	685 16 0	1846
197	40	495	203	53	1320	—	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
93	33	447	237	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 8 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	952	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1538 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	429	11	2453	2532 0 0	995 0 6	1886
510	244	1985	493	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	12	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	21	2437	2441 0 0	1417 0 11	1889
368	92	680	334	12	1775	1776 0 0	789 16 8	1890
341	152	672	107	35	1497	1664 0 0	1029 10 0	1891
413	141	733	439	50	2070	2007 0 0	864 10 0	1892
328	57	773	268	17	1661	1653 0 0	907 15 6	1893
435	69	941	451	77	2321	2175 0 0	583 15 6	1894
290	31	493	261	22	1324	1236 0 0	977 15 5	1895

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.

REPORT OF THE COUNCIL.

Report of the Council for the Year 1894–95, *presented to the General Committee at Ipswich on Wednesday, September* 11, 1895.

The Report of the Council for 1894–5 was considered and ordered to be presented to the General Committee :—

THE COUNCIL have received reports from the General Treasurer during the past year, and his accounts from July 1, 1894, to June 29, 1895, which have been audited, will be presented to the General Committee.

The Council have nominated the Mayor of Ipswich, J. H. Bartlet, Esq., M.D., Vice-President of the Association.

The invitation to hold the Annual Meeting of the Association at Toronto in 1897 has been renewed, and will be brought before the General Committee on Monday.

The election by the General Committee of Sir Douglas Galton as President of the Association for the year which begins to-day, deprives us for the future of his services as General Secretary. The Council desire to record their grateful sense of the unfailing zeal and energy which Sir Douglas Galton has displayed in the affairs of the Association during a tenure of office which has extended over twenty-four years. The Council have consequently had to consider the appointment of a successor, and desire now to nominate Professor E. A. Schäfer, F.R.S., for election to the office of General Secretary. Professor Schäfer has been communicated with, and has expressed his willingness to serve.

In accordance with a request received from the Lords of the Committee of Council on Education, who have been asked to send Delegates to the International Congress of Zoology at Leyden, the Council resolved to nominate Sir W. H. Flower to represent the Association.

The Council have elected the following Foreign Men of Science Corresponding Members :—

Prof. F. Beilstein, St. Petersburg.
Prof. Edouard van Beneden, Liège.
Prof. J. S. Billings, Deputy Surgeon-General, Washington.
Prof. D. H. Campbell, University Palo Alto, California.
M. Cartailhac, Toulouse.
Dr. A. Chauveau, Paris.
Prof. T. W. W. Engelmann, Utrecht.
Dr. Wilhelm Förster, Berlin.
Prof. Léon Fredericq, Liège.
Prof. C. Friedel, Paris.
Prof. Ludimar Hermann, Königsberg.
Prof. Dr. J. Kollmann, Basle.
M. Maxime Kovalevsky, Beaulieu-sur-Mer.
Prof. L. Kny, Berlin.
Dr. Otto Maas, Munich.
Prof. A. M. Mayer, Hoboken, New Jersey.
Prof. Gösta Mittag-Leffler, Stockholm.
Dr. Edmund von Mojsisovics, Vienna.
Prof. R. Nasini, Padua.
Prof. H. F. Osborn, Columbia College, New York.
Baron C. R. Osten-sacken, Heidelberg.
Prof. Wilhelm Pfeffer, Leipzig.
Prof. P. H. Schoute, Groningen.
Prof. E. Strasburger, Bonn.
General F. A. Walker, Boston.

Resolutions referred to the Council for consideration and action if desirable :—

(1) That the Council of the Association be requested to give their full support to the efforts being made to induce the Government to send out a fully-equipped expedition for the exploration of the Antarctic and Southern Seas.

In reference to this resolution, the Secretaries received the following communication from Mr. Clements R. Markham, President of the Royal Geographical Society :—

'I have the honour to bring to the notice of the Council of the British Association the steps that have been taken, within the last year, with a view to the renewal of Antarctic research.

'On November 27, 1893, a very important and interesting paper was read to a meeting of the Royal Geographical Society by Dr. John Murray, of the "Challenger" Expedition, a copy of which is enclosed. The arguments and the detailed information contained in Dr. Murray's paper appeared to my Council to place the importance of renewing Antarctic research in such a convincing light that they resolved to take action in the matter. I, therefore, appointed a Committee of experts to report upon the points bearing on the renewal of Antarctic research, and on the despatch of an expedition.

'On the receipt of the Report of this Society's Antarctic Committee, a copy of which I enclose, the Secretary of the Royal Society was addressed with a view to the matter receiving the consideration of the Council of that influential body. It was referred to a very strong Committee, which made its report last May, a copy of which is enclosed. The Report of this Committee of the Royal Society dwells chiefly on the requirements of magnetism, and shows the necessity for despatching an Antarctic Expedition for the completion of magnetic observations, which are both of scientific and practical importance. The Committee also points out that many other branches of science besides magnetism will be largely advanced by such an expedition ; and, referring to the present condition of the ice in the southern circumpolar region, it considers that the despatch of an expedition may assume a character of urgency.

'It is very encouraging to find that the President and Council of the Royal Society, as I am informed in a letter from the Secretary, a copy of which is enclosed, fully indorse the views of the Committee as regards the great scientific importance of the results of Antarctic research.

'The Council of the Royal Society, however, considered it their duty to raise the subject of expense, and in a private interview at the Admiralty a Deputation was informed that the Chancellor of the Exchequer, as then advised, could only confirm a doubt that had been raised whether the Imperial finances could bear the expense of the proposed expedition.

'At the present juncture the question of the cost of the expedition is irrelevant. An exaggerated estimate may have been made by those who are unacquainted with the arrangement of heads of account and other details, and who have not taken various collateral points into consideration. It will be for the members of the Deputation eventually selected by the united scientific and other bodies to ascertain the actual cost, and to place themselves in a position to answer all questions of expense, when the proper time comes for the subject of Antarctic research being brought before Her Majesty's Government for favourable consideration. They will, I believe, be able to show that the trifling expense bears no comparison with the gain to science, to the Navy, and to Imperial interests.

'Meanwhile the time has come for the leading scientific bodies of the Empire to declare, as regards their various departments, that they concur in the view already expressed by the Royal Society, the Royal Geographical Society, and the British Association, that a renewal of Antarctic research is of great importance to science.

'The Council of the British Association for the Advancement of Science was the body through whose influential representations the memorable expedition led by Sir James Ross was despatched to the Antarctic regions. True to its excellent traditions, your Council has invariably given its support to similar proposals, and I therefore feel confident that the British Association will retain its place in the front rank of those who seek to promote the advancement of science by Antarctic research.

'The President and the Council of the Royal Geographical Society now request that you will once more bring the question of the results of Antarctic discovery to the notice of your Council for serious consideration, with a view to co-operation and to the undertaking being unanimously advocated by the scientific societies of Great Britain and Ireland.'

The Council resolved to express their sympathy with, and approval of, the effort which is being made by the Royal Geographical Society to organise an expedition for the exploration of the Antarctic Sea, but did not consider that any further action could usefully be taken by them at present.

(2) That the Council be requested to call the attention of the Civil Service Commissioners to the Report of a Committee of Section F on the *Methods of Economic Training*, and especially to the recommendations (contained on page 2) with regard to the position of Economics in the Civil Service Examinations.

The following are the passages referred to in the Resolution :—

'In most Continental countries Economics occupies a place more or less prominent in the courses of training and in the examinations through which candidates for the legal profession or the Civil Service have to pass. . . .

'The two studies are cognate, and according to the view of your Committee not only would the institution of an examination in Economics at some stage of legal degrees and qualifications be advantageous professionally, but the work of those who had enjoyed a legal training would react favourably on the advance of the science. In addition, Economics should receive a much more important place in the Civil Service Examinations, and should, if possible, be made compulsory on those entering the higher branches.'

The Council, after considering this question, referred it to a Committee, consisting of the President and Officers, with Professors H. Sidgwick, Foxwell, and Edgeworth. The report of the Committee was as follows :—

'Legal studies and qualifications for the position of Barrister-at-Law depend entirely on the Inns of Court, and they believe that the Civil Service Commissioners have no influence over the legal examinations.

'The recommendations proposed with regard to the Civil Service is that Economics should, if possible, be made compulsory on those who enter the higher branches of the Service. This proposal, if carried out, would produce an entire revolution in the mode of appointing to the Civil

Service; for, as a rule, examinations are restricted to the first entry, and are not imposed on persons proceeding from a lower grade to a higher.

'It is also worthy of mature consideration whether the present is a favourable juncture for pressing on the Government a more rigid demand for economic knowledge from its servants, when the science itself is the subject of keen contention, and two schools of thought, diametrically opposed to each other, have arisen, to some extent in this country, and to a much greater extent on the Continent.

'The Committee, in view of these considerations, recommend that any further action on this matter be postponed.'

This report was adopted by the Council.

The report of the Corresponding Societies Committee for the past year, consisting of the list of the Corresponding Societies, and the titles of the more important papers, and especially those referring to Local Scientific Investigations, published by those Societies during the year ending June 1, 1895, has been received.

The account of the Conference of Delegates at Oxford has, in accordance with a resolution of the Council, been published in the Report for 1894.

The Corresponding Societies Committee, consisting of Mr. Francis Galton, Professor R. Meldola, Sir Douglas Galton, Sir Rawson Rawson, Dr. J. G. Garson, Sir J. Evans, Mr. J. Hopkinson, Mr. W. Whitaker, Mr. G. J. Symons, Professor T. G. Bonney, Mr. T. V. Holmes, Professor E. B. Poulton, Mr. Cuthbert Peek, and the Rev. Canon Tristram, is hereby nominated for re-appointment by the General Committee.

The Council nominate Mr. G. J. Symons, F.R.S., Chairman, Dr. J. G. Garson Vice-Chairman, and Mr. T. V. Holmes, Secretary, to the Conference of Delegates of Corresponding Societies to be held during the meeting at Ipswich.

In accordance with the regulations the retiring members of the Council will be :—

Professor E. Ray Lankester.
Professor G. D. Liveing.
Mr. W. H. Preece.
Professor A. W. Reinold.
Professor J. J. Thomson.

The Council recommend the re-election of the other ordinary members of the Council, with the addition of the gentlemen whose names are distinguished by an asterisk in the following list :—

Anderson, Dr. W., F.R.S.
Ayrton, Professor W. E., F.R.S.
Baker, Sir B., K.C.M.G., F.R.S.
Boys, Professor C. Vernon, F.R.S.
Edgeworth, Professor F. Y., M.A.
Evans, Sir J., K.C.B., F.R.S.
Foxwell, Professor H. S., M.A.
*Harcourt, Professor L. F. Vernon, M.A., M.Inst.C.E.
Herdman, Professor W. A., F.R.S
Horsley, Professor Victor, F.R.S.
Lodge, Professor Oliver J., F.R.S.
Markham, Clements R., Esq., C.B., F.R.S.
Meldola, Professor R., F.R.S.
*Poulton, Professor E. B., F.R.S.
Ramsay, Professor W., F.R.S.
Reynolds, Professor J. Emerson, M.D., F.R.S.
*Shaw, W. N., Esq., F.R.S.
Symons, G. J., Esq., F.R.S.
Teall, J. J. H., Esq., F.R.S.
*Thiselton-Dyer, W. T., Esq., C.M.G., F.R.S.
*Thomson, Professor J. M., F.R.S.E.
Unwin, Professor W. C., F.R S.
Vines, Professor S. H., F.R.S.
Ward, Professor Marshall, F.R.S.
Whitaker, W., Esq., F.R.S.

Committees appointed by the General Committee at the Ipswich Meeting in September 1895.

1. *Receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements. [And the unexpended balance of last year's grant in the hands of the Chairman, 18*l.* 14*s.* 6*d.*]	*Chairman.*—Professor G. Carey Foster. *Secretary.*—Mr. R. T. Glazebrook. Lord Kelvin, Professors W. E. Ayrton, J. Perry, W. G. Adams, and Oliver J. Lodge, Lord Rayleigh, Dr. John Hopkinson, Dr. A. Muirhead, Messrs. W. H. Preece and Herbert Taylor, Professors J. D. Everett and A. Schuster, Dr. J. A. Fleming, Professors G. F. FitzGerald, G. Chrystal, and J. J. Thomson, Mr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Professor J. Viriamu Jones, Dr. G. Johnstone Stoney, Professor S. P. Thompson, Mr. G. Forbes, Mr. J. Rennie, and Mr. E. H. Griffiths.	5 0 0
The Application of Photography to the Elucidation of Meteorological Phenomena.	*Chairman.*—Mr. G. J. Symons. *Secretary.*—Mr. A. W. Clayden. Professor R. Meldola and Mr. John Hopkinson.	15 0 0
For Calculating Tables of certain Mathematical Functions, and, if necessary, for taking steps to carry out the Calculations, and to publish the results in an accessible form. [The unexpended balance of last year's grant in the hands of the Chairman, 15*l.*]	*Chairman.*—Lord Rayleigh. *Secretary.*—Professor A. Lodge. Lord Kelvin, Professor B. Price, Dr. J. W. L. Glaisher, Professor A. G. Greenhill, Professor W. M. Hicks, Major P. A. Macmahon, and Lieut.-Colonel Allan Cunningham.	
Seismological Observations.	*Chairman.*—Mr. G. J. Symons. *Secretaries.*—Mr. C. Davison and Professor J. Milne. Lord Kelvin, Professor W. G. Adams, Mr. J. T. Bottomley, Sir F. J. Bramwell, Professor G. H. Darwin, Mr. Horace Darwin, Mr. G. F. Deacon, Professor J. A. Ewing, Professor A. H. Green, Professor C. G. Knott, Professor G. A. Lebour, Professor R. Meldola, Professor J. Perry, Professor J. H. Poynting, and Mr. Isaac Roberts.	80 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
To assist the Physical Society in bringing out Abstracts of Physical Papers.	*Chairman.*—Dr. E. Atkinson. *Secretary.* — Professor A. W. Rücker.	100 0 0
To co-operate with Professor Karl Pearson in the Calculation of certain Integrals. [Last year's grant renewed.]	*Chairman.*—Rev. Robert Harley. *Secretary.*—Dr. A. R. Forsyth. Mr. J. W. L. Glaisher, Professor A. Lodge, and Professor Karl Pearson.	15 0 0
To confer with British and Foreign Societies publishing Mathematical and Physical Papers as to the desirability of securing uniformity in the size of the pages of their Transactions and Proceedings. [Last year's grant renewed.]	*Chairman.*—Professor S. P. Thompson. *Secretary.*—Mr. J. Swinburne. Mr. G. H. Bryan, Mr. C. V. Burton, Mr. R. T. Glazebrook, Professor A. W. Rücker, and Dr. G. Johnstone Stoney.	5 0 0
Considering the best Methods of Recording the Direct Intensity of Solar Radiation.	*Chairman.*—Sir G. G. Stokes. *Secretary.*—Professor H. McLeod. Professor A. Schuster, Mr. G. Johnstone Stoney, Sir H. E. Roscoe, Captain W. de W. Abney, Mr. C. Chree, Mr. G. J. Symons, and Mr. W. E. Wilson.	30 0 0
Preparing a new Series of Wavelength Tables of the Spectra of the Elements.	*Chairman.*—Sir H. E. Roscoe. *Secretary.*—Dr. Marshall Watts. Mr. J. N. Lockyer, Professors J. Dewar, G. D. Liveing, A. Schuster, W. N. Hartley, and Wolcott Gibbs, and Captain Abney.	10 0 0
The Action of Light upon Dyed Colours	*Chairman.*—Dr. T. E. Thorpe. *Secretary.*—Professor J. J. Hummel. Dr. W. H. Perkin, Prof. W. J. Russell, Captain Abney, Prof. W. Stroud, and Prof. R. Meldola.	5 0 0
The Electrolytic Methods of Quantitative Analysis. [Balance of last year's grant renewed.]	*Chairman.*—Professor J. Emerson Reynolds. *Secretary.*—Dr. C. A. Kohn. Professor Frankland, Professor F. Clowes, Dr. Hugh Marshall, Mr. A. E. Fletcher, Mr. D. H Nagel, and Professor W. Carleton Williams.	10 0 0
The Carbohydrates of Barley Straw.	*Chairman.*—Professor R. Warington. *Secretary.*—Mr. Manning Prentice. Mr. C. F. Cross.	50 0 0
Publishing in pamphlet form the Papers on the Relation of Agriculture to Science, together with the discussion which followed.	*Chairman.*—Professor R. Meldola. *Secretary.*—Professor R. Warington.	5 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
To investigate the Erratic Blocks of the British Isles and to take measures for their preservation.	*Chairman.*—Professor E. Hull. *Secretary.*—Mr. P. F. Kendall. Professors T. G. Bonney, and J. Prestwich, Mr. C. E. De Rance, Professor W. J. Sollas, Mr. R. H. Tiddeman, Rev. S. N. Harrison, Mr. J. Horne, and Mr. Dugald Bell.	10 0 0
The Description and Illustration of the Fossil Phyllopoda of the Palæozoic Rocks.	*Chairman.*—Rev. Prof. T. Wiltshire. *Secretary.*—Professor T. R. Jones. Dr. H. Woodward.	5 0 0
To investigate the Character of the High-level Shell-bearing deposits at Clava, Chapelhall, and other localities.	*Chairman.*—Mr. J. Horne. *Secretary.*—Mr. Dugald Bell. Messrs. J. Fraser, P. F. Kendall, T. F. Jamieson, and David Robertson.	10 0 0
The Investigation of the Eurypterid-bearing Deposits of the Pentland Hills. [3*l.* renewed.]	*Chairman.*—Dr. R. H. Traquair. *Secretary.*—Mr. M. Laurie. Professor T. Rupert Jones.	5 0 0
To consider a project for investigating the Structure of a Coral Reef by Boring and Sounding. [Last year's grant renewed.]	*Chairman.*—Professor T. G. Bonney. *Secretary.*—Professor W. J. Sollas. Sir Archibald Geikie, Professors A. H. Green, J. W. Judd, C. Lapworth, A. C. Haddon, Boyd Dawkins, G. H. Darwin, S. J. Hickson, and A. Stewart, Admiral W. J. L. Wharton, Drs. H. Hicks, J. Murray, W. T. Blanford, Le Neve Foster, and H. B. Guppy, Messrs. F. Darwin, H. O. Forbes, G. C. Bourne, A. R. Binnie, J. W. Gregory, and J. C. Hawkshaw, and Hon. P. Fawcett.	10 0 0
To examine the ground from which the remains of *Cetiosaurus* in the Oxford Museum were obtained, with a view to determining whether other parts of the same animal remain in the rock. [20*l.* renewed.]	*Chairman.*—Professor A. H. Green. *Secretary.*—Mr. James Parker. Earl of Ducie, Professor E. Ray Lankester, Professor H. G. Seeley, and Lord Valentia.	25 0 0
To ascertain by excavation at Hoxne the relations of the Palæolithic Deposits to the Boulder Clay, and to the deposits with Arctic and Temperate plants.	*Chairman.*—Sir John Evans. *Secretary.*—Mr. Clement Reid. Miss E. Morse, Mr. E. P. Ridley, and Mr. H. N. Ridley.	25 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants £ s. d.
To explore certain Caves in the Neighbourhood of Singapore, and to collect their living and extinct Fauna.	*Chairman.*—Sir W. H. Flower. *Secretary.*—Mr. H. N. Ridley. Dr. R. Hanitsch, Mr. Clement Reid, and Mr. A. Russel Wallace.	40 0 0
To ascertain the Age and Relations of the Rocks in which Secondary Fossils have been found near Moreseat, Aberdeenshire.	*Chairman.*—Mr. T. F. Jamieson. *Secretary.*—Mr. J. Milne. Mr. A. J. Jukes-Browne.	10 0 0
To enable Mr. H. C. Williamson to investigate the Fertilisation of the Eel, and the Development of the testis in Teleostean Fishes, or, failing this, to appoint some other competent investigator to carry on a definite piece of work at the Zoological Station at Naples.	*Chairman.*—Dr. P. L. Sclater. *Secretary.*—Mr. Percy Sladen. Professor E. Ray Lankester, Professor J. Cossar Ewart, Professor M. Foster, Professor S. J. Hickson, Mr. A. Sedgwick, and Professor W. C. M'Intosh.	100 0 0
To enable Mr. Darnell Smith or other naturalist to investigate the relations between physical conditions and marine Fauna and Flora, at the Laboratory of the Marine Biological Association, Plymouth. [5*l.* renewed.]	*Chairman.*—Mr. G. C. Bourne. *Secretary.* — Professor E. Ray Lankester. Professor M. Foster and Professor S. H. Vines.	15 0 0
The Zoology, Botany, and Geology of the Irish Sea.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Mr. I. C. Thompson. Professor A. C. Haddon, Professor G. B. Howes, Mr. W. E. Hoyle, Mr. A. O. Walker, Mr. Clement Reid, Professor F. E. Weiss, Dr. H. O. Forbes, and Mr. G. W. Lamplugh.	50 0 0
To report on the present state of our Knowledge of the Zoology of the Sandwich Islands, and to take steps to investigate ascertained deficiencies in the Fauna, with power to co-operate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance in their investigations as may be offered by the Hawaiian Government. The Committee to have power to dispose of specimens where advisable.	*Chairman.*—Professor A. Newton. *Secretary.*—Dr. David Sharp. Dr. W. T. Blanford, Professor S. J. Hickson, Mr. O. Salvin, Dr. P. L. Sclater, and Mr. Edgar A. Smith.	100 0 0

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
The Investigation of the African Lake Fauna by Mr. J. E. Moore.	*Chairman.*—Dr. P. L. Sclater. *Secretary.*—Professor G. B. Howes. Dr. John Murray, Professor E. Ray Lankester, and Professor W. A. Herdman.	100 0 0
The Elucidation of the Life Conditions of the Oyster under Normal and Abnormal Environment, including in the latter the effect of sewage matter and pathogenic organisms.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Professor R. Boyce. Mr. G. C. Bourne and Professor C. S. Sherrington.	40 0 0
Climatology of Tropical Africa.	*Chairman.*—Mr. E. G. Ravenstein. *Secretary.*—Mr. H. N. Dickson. Sir John Kirk, Dr. H. R. Mill, and Mr. G. J. Symons.	10 0 0
To report on methods of Calibrating the measuring instruments used in Engineering Laboratories, and to take steps for Comparing the Measuring Instruments at present in use in different laboratories. [25*l.* renewed.]	*Chairman.*—Professor A. B. W. Kennedy. *Secretary.*—Professor W. C. Unwin.	30 0 0
To consider means by which better practical effect can be given to the Introduction of the Screw Gauge proposed by the Association in 1884.	*Chairman.*—Mr. W. H. Preece. *Secretary.*—Mr. Conrad W. Cooke. Lord Kelvin, Sir F. J. Bramwell, Sir H. Trueman Wood, Maj.-Gen. Webber, Mr. R. E. Crompton, Mr. A. Stroh, Mr. A. Le Neve Foster, Mr. T. P. Hewitt, Mr. G. K. B. Elphinstone, and Mr. T. Buckney.	10 0 0
The Physical Characters, Languages, and Industrial and Social Condition of the North-Western Tribes of the Dominion of Canada.	*Chairman.*—Professor E. B. Tylor. *Secretary.*—Mr. Cuthbert E. Peek. Dr. G. M. Dawson, Mr. R. G. Haliburton, and Mr. H. Hale.	100 0 0
The Lake Village at Glastonbury.	*Chairman.*—Dr. R. Munro. *Secretary.*—Mr. A. Bulleid. Professor W. Boyd Dawkins, General Pitt-Rivers, Sir John Evans, and Mr. Arthur J. Evans.	30 0 0
An ancient Kitchen-midden at Hastings already partially examined, and a Settlement called the Wildernesse. [Unexpended balance in the hands of the Chairman 2*l.* 6*s.* 6*d.*]	*Chairman.*—Sir John Evans. *Secretary.*—Mr. W. J. Lewis Abbott. Professor Prestwich, Mr. Cuthbert Peek, and Mr. Arthur J. Evans.	

1. *Receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee	Grants
		£ s. d.
To organise an Ethnographical Survey of the United Kingdom. [20*l.* renewed.]	*Chairman.*—Mr. E. W. Brabrook. *Secretary.*—Mr. E. Sidney Hartland. Mr. Francis Galton, Dr. J. G. Garson, Professor A. C. Haddon, Dr. Joseph Anderson, Mr. J. Romilly Allen, Dr. J. Beddoe, Professor D. J. Cunningham, Professor W. Boyd Dawkins, Mr. Arthur J. Evans, Mr. F. G. Hilton Price, Sir H. Howorth, Professor R. Meldola, General Pitt-Rivers, and Mr. E. G. Ravenstein.	40 0 0
To co-operate with the Committee appointed by the International Congress of Hygiene and Demography in the investigation of the Mental and Physical Condition of Children.	*Chairman.*—Sir Douglas Galton. *Secretary.*—Dr. Francis Warner. Mr. E. W. Brabrook, Dr. J. G. Garson, Dr. W Wilberforce Smith, and Mr. White Wallis.	10 0 0
To carry out an investigation on the Physiological Applications of the Phonograph, and on the true form of the voice curves made by the instrument.	*Chairman.*—Professor J. G. McKendrick. *Secretary.*—Professor G. G. Murray. Mr. David S. Wingate and Mr. John S. McKendrick.	25 0 0
Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Professor R. Meldola. *Secretary.*—Mr. T. V. Holmes. Mr. Francis Galton, Sir Douglas Galton, Sir Rawson Rawson, Mr. G. J. Symons, Dr. J. G. Garson, Sir John Evans, Mr. J. Hopkinson, Professor T. G. Bonney, Mr. W. Whitaker, Professor E. B. Poulton, Mr. Cuthbert Peek, and Rev. Canon H. B. Tristram.	30 0 0
Anthropometric Measurements in Schools. [Unexpended balance in the hands of the Chairman 2*l.* 14*s.*]	*Chairman.*—Professor A. Macalister. *Secretary.*—Professor B. Windle. Mr. E. W. Brabrook, Professor J. Cleland, and Dr. J. G. Garson.	

2. *Not receiving Grants of Money.*

Subject for Investigation or Purpose	Members of the Committee
Co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.	*Chairman.*—Lord McLaren. *Secretary.*—Professor Crum Brown. Mr. John Murray, Dr. A. Buchan, Professor R. Copeland, and Hon. R. Abercromby.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To confer with the Astronomer Royal and the Superintendents of other Observatories with reference to the Comparison of Magnetic Standards with a view of carrying out such comparison.	*Chairman.*—Professor A. W. Rücker. *Secretary.*—Mr. W. Watson. Professor A. Schuster and Professor H. H. Turner.
Comparing and Reducing Magnetic Observations.	*Chairman.*—Professor W. G. Adams. *Secretary.*—Mr. C. Chree. Lord Kelvin, Professor G. H. Darwin, Professor G. Chrystal, Professor A. Schuster, Captain E. W. Creak, the Astronomer Royal, Mr. William Ellis, and Professor A. W. Rücker.
The Collection and Identification of Meteoric Dust.	*Chairman.*—Mr. John Murray. *Secretary.*—Mr. John Murray. Professor A. Schuster, Lord Kelvin, the Abbé Renard, Dr. A. Buchan, the Hon. R. Abercromby, Dr. M. Grabham, Mr. John Aitken, Mr. L. Fletcher, and Mr. A. Ritchie Scott.
The Rate of Increase of Underground Temperature downwards in various Localities of dry Land and under Water.	*Chairman.*—Professor J. D. Everett. *Secretary.*—Professor J. D. Everett. Professor Lord Kelvin, Mr. G. J. Symons, Sir A. Geikie, Mr. J. Glaisher, Professor Edward Hull, Professor J. Prestwich, Dr. C. Le Neve Foster, Professor A. S. Herschel, Professor G. A. Lebour, Mr. A. B. Wynne, Mr. W. Galloway, Mr. Joseph Dickinson, Mr. G. F. Deacon, Mr. E. Wethered, Mr. A. Strahan, and Professor Michie Smith.
The present state of our Knowledge in Electrolysis and Electro-chemistry.	*Chairman.*—Mr. W. N. Shaw. *Secretary.*—Mr. W. C. D. Whetham. Rev. T. C. Fitzpatrick.
That Mr. John Brill be requested to draw up a Report on Non-commutative Algebras.	—
That Professor S. P. Thompson and Professor A. W. Rücker be requested to draw up a Report on the State of our Knowledge concerning Resultant Tones.	—
The mode of Teaching Geometrical Drawing in Schools.	*Chairman.*—Professor O. Henrici. *Secretary.*—Professor O. Henrici. Captain Abney, Dr. J. H. Gladstone, Mr. R. B. Hayward, Professor Karl Pearson, Professor W. Cawthorne Unwin.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
The Establishment of a National Physical Laboratory for the more accurate determination of Physical Constants, and for other Quantitative Research, and to confer with the Council of the Association.	*Chairman.*—Sir Douglas Galton. *Secretary.*—Professor O. J. Lodge. Lord Rayleigh, Lord Kelvin, Sir H. E. Roscoe, Professor A. W. Rücker, Professor R. B. Clifton, Professor Carey Foster, Professor A. Schuster, Professor W. E. Ayrton, Dr. W. Anderson, Dr. T. E. Thorpe, Mr. Francis Galton, and Mr. R. T. Glazebrook.
The Investigation of the direct Formation of Haloids from pure Materials.	*Chairman.*—Professor H. E. Armstrong. *Secretary.*—Mr. W. A. Shenstone. Professor W. R. Dunstan and Mr. C. H. Bothamley.
Isomeric Naphthalene Derivatives.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Professor H. E. Armstrong.
The Properties of Solutions.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Dr. W. W. J. Nicol. Professor W. Ramsay.
Reporting on the Bibliography of Solution.	*Chairman.*—Professor W. A. Tilden. *Secretary.*—Dr. W. W. J. Nicol. Professors H. McLeod, S. U. Pickering, W. Ramsay, and S. Young.
The Continuation of the Bibliography of Spectroscopy.	*Chairman.*—Professor H. McLeod. *Secretary.*—Professor Roberts-Austen. Mr. H. G. Madan and Mr. D. H. Nagel.
The Action of Light on the Hydracids of the Halogens in presence of Oxygen.	*Chairman.*—Dr. W. J. Russell. *Secretary.*—Dr. A. Richardson. Captain Abney, Professor W. Noel Hartley and Professor W. Ramsay.
To inquire into the Proximate Chemical Constituents of the various kinds of Coal.	*Chairman.*—Sir I. Lowthian Bell *Secretary.*—Professor P. Phillips Bedson. Professor F. Clowes, Mr. Ludwig Mond, Professors Vivian B. Lewes and E. Hull, and Messrs. J. W. Thomas and H. Bauerman.
The Teaching of Natural Science in Elementary Schools.	*Chairman.*—Dr. J. H. Gladstone. *Secretary.*—Professor H. E. Armstrong. Mr. George Gladstone, Professor W. R. Dunstan, Sir J. Lubbock, Sir Philip Magnus, Sir H. E. Roscoe, and Dr. Silvanus P. Thompson.
The Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	*Chairman.*—Professor J. Geikie. *Secretaries.*—Mr. O. W. Jeffs, and Mr. W. W. Watts. Prof. T. G. Bonney, Prof. W. Boyd Dawkins, Prof. T. McKenny Hughes, Dr. T. Anderson, and Messrs. A. S. Reid, E. J. Garwood, W. Gray, H. B. Woodward, J. E. Bedford, R. Kidston, R. H. Tiddeman, J. J. H. Teall, and J. G. Goodchild.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
To open further Sections in the neighbourhood of Stonesfield in order to show the relationship of the 'Stonesfield Slate' to the underlying and overlying strata.	*Chairman.*—Mr. H. B. Woodward. *Secretary.*—Mr. E. A. Walford. Professor A. H. Green, Dr. H. Woodward, and Mr. J. Windoes.
To explore the Calf-Hole Cave, at the Heights, Skyrethorne, near Skipton.	*Chairman.*—Mr. R. H. Tiddeman. *Secretary.*—Rev. E. Jones. Professor W. Boyd Dawkins, Professor L. C. Miall, Mr. P. F. Kendall, Mr. A. Birtwhistle, and Mr. J. J. Wilkinson.
To investigate the nature and probable age of the High-level Flint-drift in the Face of the Chalk Escarpment near Ightham.	*Chairman.*—Sir John Evans. *Secretary.*—Mr. B. Harrison. Professor J. Prestwich and Professor H. G. Seeley.
To consider the best Methods for the Registration of all Type Specimens of Fossils in the British Isles, and to report on the same.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Mr. A. Smith Woodward. Rev. G. F. Whidborne, Mr. R. Kidston, and Mr. J. E. Marr.
To study Life Zones in the British Carboniferous Rocks.	*Chairman.*—Mr. J. E. Marr. *Secretary.*—Mr. E. J. Garwood. Mr. A. H. Foord.
To report on the present state of our Knowledge of the Zoology and Botany of the West India Islands, and to take steps to investigate ascertained deficiencies in the Fauna and Flora.	*Chairman.*—Dr. P. L. Sclater. *Secretary.*—Mr. G. Murray. Mr. W. Carruthers, Dr. A. C. Günther, Dr. D. Sharp, Mr. F. Du Cane Godman, and Professor A. Newton.
Compilation of an Index Generum et Specierum Animalium.	*Chairman.*—Sir W. H. Flower. *Secretary.*—Mr. W. Sclater. Dr. P. L. Sclater and Dr. H. Woodward.
To make a Digest of the Observations on the Migration of Birds at Lighthouses and Light-vessels.	*Chairman.*—Professor A. Newton. *Secretary.*—Mr. John Cordeaux. Mr. John A. Harvie-Brown, Mr. R. M. Barrington, Mr. W. E. Clarke, and Rev. E. P. Knubley.
Investigation into the Life History and Economic Relations of the Coccidæ of Ceylon by Mr. E. E. Green.	*Chairman.*—Mr. R. McLachlan. *Secretary.*—Professor G. B. Howes. Lord Walsingham, Professor R. Meldola, Professor L. C. Miall, Mr. R. Newstead, Dr. D. Sharp, and Colonel C. Swinhoe.
Zoological Bibliography and Publication.	*Chairman.*—Sir W. H. Flower. *Secretary.*—Mr. F. A. Bather. Professor W. A. Herdman, Mr. W. E. Hoyle, Dr. P. Lutley Sclater, Mr. Adam Sedgwick, Dr. D. Sharp, Mr. C. D. Sherborn, Rev. T. R. R. Stebbing, and Professor W. F. R. Weldon.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation or Purpose	Members of the Committee
Regulations of the Post Office regarding the carriage of Natural History specimens to Foreign Countries.	*Chairman.*—Lord Walsingham. *Secretary.*—Dr. H. O. Forbes. Mr. R. McLachlan, Dr. C. W. Stiles, and Colonel C. Swinhoe.
The Necessity for the immediate investigation of the Biology of Oceanic Islands.	*Chairman.*—Sir W. H. Flower. *Secretary.*—Professor A. C. Haddon. Mr. G. C. Bourne, Dr. H. O. Forbes, Professor W. A. Herdman, Professor S. J. Hickson, Dr. John Murray, Professor A. Newton, Mr. A. E. Shipley, and Professor W. F. R. Weldon
The position of Geography in the Educational System of the Country.	*Chairman.*—Mr. H. J. Mackinder. *Secretary.*—Mr. A. J. Herbertson. Mr. J. S. Keltie, Dr. H. R. Mill, Mr. E. G. Ravenstein, and Mr. Eli Sowerbutts.
The effect of wind and atmospheric pressure on the Tides.	*Chairman.*—Professor L. F. Vernon Harcourt. *Secretary.*—Mr. W. H. Wheeler. Mr. G. F. Deacon, and Professor W. C. Unwin.
For carrying on the Work of the Anthropometric Laboratory.	*Chairman.*—Sir W. H. Flower. *Secretary.*—Dr. J. G. Garson. Dr. Wilberforce Smith, Professor A. C. Haddon, and Professor B. C. A. Windle.
The Prehistoric and Ancient Remains of Glamorganshire.	*Chairman.*—Dr. C. T. Vachell. *Secretary.*—Mr. E. Seward. Lord Bute, Messrs. R. W. Atkinson, Franklen G. Evans, James Bell, and T. H. Thomas, and Dr. J. G. Garson.
Linguistic and Anthropological Characteristics of the North Dravidians—the Ura-ons.	*Chairman.*—Mr. E. Sidney Hartland. *Secretary.*—Mr. Hugh Raynbird, jun. Professor A. C. Haddon and Mr. J. L. Myres.
The best methods of preserving Vegetable Specimens for Exhibition in Museums.	*Chairman.*—Dr. D. H. Scott. *Secretary.*—Professor J. B. Farmer. Professor Bayley Balfour, Professor Errera, Mr. W. Gardiner, Professor J. R. Green, Professor J. W. H. Trail, and Professor F. E. Weiss.

Communications ordered to be printed in extenso.

Professor R. Warington's paper on 'How shall Agriculture best receive help from Science?'

Mr. W. Whitaker's paper on 'Some Suffolk Wells.'

Mr. Joseph Francis's paper on 'The Dip of the Underground Palæozoic Rocks at Ware and Cheshunt.'

Regulations regarding Grants of Money.

The regulations were revised, and are given on p. xxxii.

Resolutions referred to the Council for consideration, and action if desirable.

That the Council be requested to consider whether it be desirable to take steps in order to bring the following resolution under the notice of H.M. Government and the Trustees of the British Museum:—

'That in view of the importance of preserving the remains of the various civilisations of this Empire which are fast disappearing, and in order to prevent the loss and dispersion of collections of ancient and modern Anthropology which may be offered to the nation, it is highly desirable to acquire less costly and far more extended storehouse space than can be provided in London.'

That the Council be requested to bring before the Government the importance of securing for the National Collections the type collection of preparations of Fossil Plants left by the late Professor W. C. Williamson.

That it is desirable to reprint collections of the Addresses delivered by the Presidents of Sections in separate volumes for sale.

That the Council be requested to provide the Geological Survey maps and sections of the district in which the Association meets each year, to be placed in a conspicuous position in the Meeting Room of Section C.

Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Ipswich Meeting, September 1895. The Names of the Members entitled to call on the General Treasurer for the respective Grants are prefixed.

Mathematics and Physics.

	£	s.	d.
*Foster, Professor Carey—Electrical Standards (And unexpended balance 18*l.* 14*s.* 6*d.*)	5	0	0
*Symons, Mr. G. J.—Photographs of Meteorological Phenomena	15	0	0
*Rayleigh, Lord—Mathematical Tables (Unexpended balance 15*l.*)	—		
*Symons, Mr. G. J.—Seismological Observations	80	0	0
*Atkinson, Dr. E.—Abstracts of Physical Papers	100	0	0
*Harley, Rev. R.—Calculation of Certain Integrals (Renewed)	15	0	0
Thompson, Professor S. P.—Uniformity of Size of Pages of Transactions, &c. (Renewed)	5	0	0
*Stokes, Sir G. G.—Solar Radiation	30	0	0

Chemistry.

*Roscoe, Sir H. E.—Wave-length Tables of the Spectra of the Elements	10	0	0
*Thorpe, Dr. T. E.—Action of Light upon Dyed Colours	5	0	0
*Reynolds, Professor J. E.—Electrolytic Quantitative Analysis (Renewed)	10	0	0
Warington, Professor R.—The Carbohydrates of Barley Straw	50	0	0
Meldola, Professor R.—Reprinting Discussion on the Relation of Agriculture to Science	5	0	0

Geology.

*Hull, Professor E.—Erratic Blocks	10	0	0
*Wiltshire, Professor T.—Palæozoic Phyllopoda	5	0	0
*Horne, Mr. J.—Shell-bearing Deposits at Clava, &c.	10	0	0
*Traquair, Dr. R. H.—Eurypterids of the Pentland Hills (3*l.* renewed)	5	0	0
*Bonney, Professor T. G.—Investigation of a Coral Reef by Boring and Sounding (Renewed)	10	0	0
*Green, Professor A. H.—Examination of Locality where the Cetiosaurus in the Oxford Museum was found. (20*l.* renewed)	25	0	0
Evans, Sir John—Palæolithic Deposits at Hoxne	25	0	0
Flower, Sir W. H.—Fauna of Singapore Caves	40	0	0
Jamieson, Mr. T. F.—Age and Relation of Rocks near Moreseat, Aberdeen	10	0	0
Carried forward	£470	0	0

* Reappointed.

	£	s.	d.
Brought forward	470	0	0
Zoology.			
*Sclater, Dr. P. L.—Table at the Zoological Station, Naples	100	0	0
*Bourne, Mr. G. C.—Table at the Biological Laboratory, Plymouth (5*l.* renewed)	15	0	0
*Herdman, Professor W. A.—Zoology, Botany, and Geology of the Irish Sea	50	0	0
*Sclater, Dr. P. L.—Zoology of the Sandwich Islands	100	0	0
Sclater, Dr. P. L.—African Lake Fauna	100	0	0
Herdman, Professor W. A.—Oysters under normal and abnormal environment	40	0	0
Geography.			
*Ravenstein, Mr. E. G.—Climatology of Tropical Africa	10	0	0
Mechanical Science.			
Kennedy, Professor A. B. W.—Calibration and Comparison of Measuring Instruments (25*l.* renewed)	30	0	0
*Preece, Mr. W. H.—Small Screw Gauge	10	0	0
Anthropology.			
*Tylor, Professor E. B.—North-Western Tribes of Canada (76*l.* 15*s.* renewed)	100	0	0
*Munro, Dr. R.—Lake Village at Glastonbury (5*l.* renewed)	30	0	0
*Evans, Sir J.—Exploration of a Kitchen-midden at Hastings (Unexpended balance 2*l.* 6*s.* 6*d.*)	—		
*Brabrook, Mr. E. W.—Ethnographical Survey (20*l.* renewed)	40	0	0
*Galton, Sir Douglas—Mental and Physical Condition of Children	10	0	0
*Flower, Sir W. H.—Anthropometric Measurements in Schools (Unexpended balance, 2*l.* 14*s.*)	—		
Physiology.			
*McKendrick, Professor J. G.—Physiological Applications of the Phonograph	25	0	0
Corresponding Societies.			
*Meldola, Professor R.—Preparation of Report	30	0	0
	£1,160	0	0

* Reappointed.

The Annual Meeting in 1896.

The Meeting at Liverpool will commence on Wednesday, September 16.

The Annual Meeting in 1897.

The Annual Meeting of the Association in 1897 will be held at Toronto, Canada.

General Statement of Sums which have been paid on account of Grants for Scientific Purposes.

1834.

	£	s.	d.
Tide Discussions	20	0	0

1835.

	£	s.	d.
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0

1836.

	£	s.	d.
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on Long-continued Heat	17	1	0
Rain-gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0

1837.

	£	s.	d.
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6

1838.

	£	s.	d.
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2

1839.

	£	s.	d.
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	0
Cast-iron Experiments	103	0	7
Railway Constants	28	7	0
Land and Sea Level	274	1	2
Steam-vessels' Engines	100	0	4
Stars in Histoire Céleste	171	18	0
Stars in Lacaille	11	0	6
Stars in R.A.S. Catalogue	166	16	0
Animal Secretions	10	10	6
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0

1840.

	£	s.	d.
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

1841.

	£	s.	d.
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Firth of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8

	£	s.	d.
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland ...	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment at Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells ...	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology.........1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu......	10	0	0
Experiments on the Vitality of Seeds	9	0	0
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals......	50	0	0
Constant Indicator and Morin's Instrument 1842	10	0	0
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh................	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment at Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces...	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall .	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York..	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay............................	100	0	0
Computation of the Gaussian Constants for 1829	5	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain ...	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers..........................	11	7	6
Anemometers' Repairs.........	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

1851.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

	£	s.	d.
Maintaining the Establishment at Kew Observatory :— 1854......£ 75 0 0; 1855......£500 0 0	575	0	0

	£	s.	d.
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	0
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seeds	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860......£50 0 0; 1861......£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahagow	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland Coasts	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east Coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging, Shetland	75	0	0
Dredging, Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-gauges	19	15	8
Cast-iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-gauges	30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-bed ...	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation ...	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards	100	0	0
Malta Caves Exploration	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast ...	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	20	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches ...	30	0	0
Palestine Exploration Fund...	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Meteorological Instruments, Palestine	50	0	0
Lunar Committee	120	0	0
Metrical Committee	30	0	0
Kent's Hole Explorations ...	100	0	0
Palestine Explorations	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-bed ...	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards	100	0	0
Ethyl and Methyl Series	25	0	0
Fossil Crustacea	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
Do. Plant Beds	100	0	0
Iron and Steel Manufacture...	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record	100	0	0
Kent's Hole Explorations ...	150	0	0
Steamship Performances	100	0	0
British Rainfall	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall..	30	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	50	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Gases in Deep-well Water	25	0	0
British Rainfall	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	30	0	0
Chemical Constitution of Cast Iron	80	0	0
Iron and Steel Manufacture	100	0	0
Methyl Series	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals	50	0	0
Bagshot Leaf-beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids	12	0	0
Kiltorcan Fossils	20	0	0

	£	s.	d.
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observations	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorology	100	0	0
Magnetisation of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone-corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetisation of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0
Specific Volume of Liquids	25	0	0
Estimation of Potash and Phosphoric Acid	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations	100	0	0
Kent's Cavern Exploration	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record	100	0	0
Instructions for Travellers	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall	100	0	0
Ohm's Law	9	15	0
Tide Calculating Machine	200	0	0
Specific Volume of Liquids	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	5	0	0
Estimation of Potash and Phosphoric Acid	13	0	0
Exploration of Victoria Cave	100	0	0
Geological Record	100	0	0
Kent's Cavern Exploration	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland	1	10	0
Zoological Record	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Naples Zoological Station	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles	13	15	0
Measuring Speed of Ships	10	0	0
Effect of Propeller on turning of Steam-vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acid in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpeæ, Report on	20	0	0
Mechanical Equivalent of Heat	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperature	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	10	0	0
British Earthworks	25	0	0
Atmospheric Electricity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid	1	18	0
Geological Record	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c.	15	0	0
	£1128	9	7

1878.

	£	s.	d.
Exploration of Settle Caves	100	0	0
Geological Record	100	0	0
Investigation of Pulse Phenomena by means of Siphon Recorder	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters	15	0	0
Transmission of Electrical Impulses through Nerve Structure	30	0	0
Calculation of Factor Table for 4th Million	100	0	0
Anthropometric Committee...	66	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland ...	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration ...	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts	25	0	0
Anthropometric Committee...	50	0	0
Natural History of Socotra ...	100	0	0
Calculation of Factor Tables for 5th and 6th Millions ...	150	0	0
Underground Waters	10	0	0
Steering of Screw Steamers...	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature ...	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration ...	50	0	0
Geological Record	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

1881.

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature ...	20	0	0
Electrical Standards........ ...	25	0	0
High Insulation Key............	5	0	0
Tidal Observations	10	0	0
Specific Refractions	7	3	1
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station ...	50	0	0
Naples Zoological Station ...	75	0	0
Natural History of Socotra ...	50	0	0
Anthropological Notes and Queries	9	0	0
Zoological Record..............	100	0	0
Weights and Heights of Human Beings	30	0	0
	£476	3	1

1882.

	£	s.	d.
Exploration of Central Africa	100	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Standards for Electrical Measurements	100	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements..............	50	0	0
Photographing Ultra-violet Spark Spectra	25	0	0
Geological Record..............	100	0	0
Earthquake Phenomena of Japan	25	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Fossil Plants of Halifax	15	0	0
Geological Map of Europe ...	25	0	0
Circulation of Underground Waters..........................	15	0	0
Tertiary Flora of North of Ireland	20	0	0
British Polyzoa	10	0	0
Exploration of Caves of South of Ireland	10	0	0
Exploration of Raygill Fissure	20	0	0
Naples Zoological Station ...	80	0	0
Albuminoid Substances of Serum	10	0	0
Elimination of Nitrogen by Bodily Exercise...............	50	0	0
Migration of Birds	15	0	0
Natural History of Socotra...	100	0	0
Natural History of Timor-laut	100	0	0
Record of Zoological Literature	100	0	0
Anthropometric Committee...	50	0	0
	£1126	1	11

1883.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Isomeric Naphthalene Derivatives........................	15	0	0
Earthquake Phenomena of Japan	50	0	0
Fossil Plants of Halifax	20	0	0
British Fossil Polyzoa	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Circulation of Underground Waters..........................	15	0	0
Geological Record..............	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Zoological Literature Record	100	0	0
Migration of Birds	20	0	0
Zoological Station at Naples	80	0	0
Scottish Zoological Station...	25	0	0
Elimination of Nitrogen by Bodily Exercise..............	38	3	3
Exploration of Mount Kilima-njaro..........................	500	0	0
Investigation of Loughton Camp	10	0	0
Natural History of Timor-laut	50	0	0
Screw Gauges....................	5	0	0
	£1083	3	3

1884.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Collecting and Investigating Meteoric Dust.................	20	0	0
Meteorological Observatory at Chepstow.......................	25	0	0
Tidal Observations..............	10	0	0
Ultra Violet Spark Spectra ...	8	4	0
Earthquake Phenomena of Japan	75	0	0
Fossil Plants of Halifax	15	0	0
Fossil Polyzoa....................	10	0	0
Erratic Blocks of England ...	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Circulation of Underground Waters..........................	5	0	0
International Geological Map	20	0	0
Bibliography of Groups of Invertebrata	50	0	0
Natural History of Timor-laut	50	0	0
Naples Zoological Station ...	80	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Migration of Birds..............	20	0	0
Coagulation of Blood...........	100	0	0
Zoological Literature Record	100	0	0
Anthropometric Committee...	10	0	0
	£1173	4	0

1885.

	£	s.	d.
Synoptic Chart of Indian Ocean	50	0	0
Reduction of Tidal Observations	10	0	0
Calculating Tables in Theory of Numbers	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Meteoric Dust	70	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions	20	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Raygill Fissure	15	0	0
Earthquake Phenomena of Japan	70	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Fossil Plants of British Tertiary and Secondary Beds	50	0	0
Geological Record	50	0	0
Circulation of Underground Waters	10	0	0
Naples Zoological Station	100	0	0
Zoological Literature Record	100	0	0
Migration of Birds	30	0	0
Exploration of Mount Kilimanjaro	25	0	0
Recent Polyzoa	10	0	0
Granton Biological Station	100	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Exploration of New Guinea	200	0	0
Exploration of Mount Roraima	100	0	0
	£1385	0	0

1886.

	£	s.	d.
Electrical Standards	40	0	0
Solar Radiation	9	10	6
Tidal Observations	50	0	0
Magnetic Observations	10	10	0
Observations on Ben Nevis	100	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
Chemical Nomenclature	5	0	0
Fossil Plants of British Tertiary and Secondary Beds	20	0	0
Caves in North Wales	25	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Geological Record	100	0	0
Palæozoic Phyllopoda	15	0	0
Zoological Literature Record	100	0	0
Granton Biological Station	75	0	0
Naples Zoological Station	50	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Migration of Birds	30	0	0
Secretion of Urine	10	0	0
Exploration of New Guinea	150	0	0
Regulation of Wages under Sliding Scales	10	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada	50	0	0
	£995	0	6

1887.

	£	s.	d.
Solar Radiation	18	10	0
Electrolysis	30	0	0
Ben Nevis Observatory	75	0	0
Standards of Light (1886 grant)	20	0	0
Standards of Light (1887 grant)	10	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Magnetic Observations	26	2	0
Electrical Standards	50	0	0
Silent Discharge of Electricity	20	0	0
Absorption Spectra	40	0	0
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Cae Gwyn Cave, N. Wales	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	20	0	0
Coal Plants of Halifax	25	0	0
Microscopic Structure of the Rocks of Anglesey	10	0	0
Exploration of the Eocene Beds of the Isle of Wight	20	0	0
Underground Waters	5	0	0
'Manure' Gravels of Wexford	10	0	0
Provincial Museums Reports	5	0	0
Lymphatic System	25	0	0
Naples Biological Station	100	0	0
Plymouth Biological Station	50	0	0
Granton Biological Station	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Flora and Fauna of the Cameroons	75	0	0
Migration of Birds	30	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Regulation of Wages	10	0	0
Prehistoric Race of Greek Islands	20	0	0
Racial Photographs, Egyptian	20	0	0
	£1186	18	0

1888.

	£	s.	d.
Ben Nevis Observatory	150	0	0
Electrical Standards	2	6	4
Magnetic Observations	15	0	0
Standards of Light	79	2	3
Electrolysis	30	0	0
Uniform Nomenclature in Mechanics	10	0	0
Silent Discharge of Electricity	9	11	10
Properties of Solutions	25	0	0
Influence of Silicon on Steel	20	0	0
Methods of Teaching Chemistry	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Action of Light on Hydracids	20	0	0
Sea Beach near Bridlington	20	0	0
Geological Record	50	0	0
Manure Gravels of Wexford	10	0	0
Erosion of Sea Coasts	10	0	0
Underground Waters	5	0	0
Palæontographical Society	50	0	0
Pliocene Fauna of St. Erth	50	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Zoology and Botany of West Indies	100	0	0
Flora of Bahamas	100	0	0
Development of Fishes—St. Andrews	50	0	0
Marine Laboratory, Plymouth	100	0	0
Migration of Birds	30	0	0
Flora of China	75	0	0
Naples Zoological Station	100	0	0
Lymphatic System	25	0	0
Biological Station at Granton	50	0	0
Peradeniya Botanical Station	50	0	0
Development of Teleostei	15	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Effect of Occupations on Physical Development	25	0	0
North-Western Tribes of Canada	100	0	0
Prehistoric Race in Greek Islands	20	0	0
	£1511	0	5

1889.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	75	0	0
Electrolysis	20	0	0
Surface Water Temperature	30	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids	10	0	0
Geological Record	80	0	0
Volcanic Phenomena of Japan	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	20	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
West Indian Explorations	100	0	0
Flora of China	25	0	0
Naples Zoological Station	100	0	0
Physiology of Lymphatic System	25	0	0
Experiments with a Tow-net	5	16	3
Natural History of Friendly Islands	100	0	0
Geology and Geography of Atlas Range	100	0	0
Action of Waves and Currents in Estuaries	100	0	0
North-Western Tribes of Canada	150	0	0
Nomad Tribes of Asia Minor	30	0	0
Corresponding Societies	20	0	0
Marine Biological Association	200	0	0
'Baths Committee,' Bath	100	0	0
	£1417	0	11

1890.

	£	s.	d.
Electrical Standards	12	17	0
Electrolysis	5	0	0
Electro-optics	50	0	0
Mathematical Tables	25	0	0
Volcanic and Seismological Phenomena of Japan	75	0	0
Pellian Equation Tables	15	0	0
Properties of Solutions	10	0	0
International Standard for the Analysis of Iron and Steel	10	0	0
Influence of the Silent Discharge of Electricity on Oxygen	5	0	0
Methods of teaching Chemistry	10	0	0
Recording Results of Water Analysis	4	1	0
Oxidation of Hydracids in Sunlight	15	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	10	0	0
Circulation of Underground Waters	5	0	0
Excavations at Oldbury Hill	15	0	0
Cretaceous Polyzoa	10	0	0
Geological Photographs	7	14	11
Lias Beds of Northampton	25	0	0
Botanical Station at Peradeniya	25	0	0

	£	s.	d.
Experiments with a Tow-net	4	3	9
Naples Zoological Station ...	100	0	0
Zoology and Botany of the West India Islands	100	0	0
Marine Biological Association	30	0	0
Action of Waves and Currents in Estuaries	150	0	0
Graphic Methods in Mechanical Science	11	0	0
Anthropometric Calculations	5	0	0
Nomad Tribes of Asia Minor	25	0	0
Corresponding Societies	20	0	0
	£799	16	8

1891.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	100	0	0
Electrolysis	5	0	0
Seismological Phenomena of Japan	10	0	0
Temperatures of Lakes	20	0	0
Photographs of Meteorological Phenomena	5	0	0
Discharge of Electricity from Points	10	0	0
Ultra Violet Rays of Solar Spectrum	50	0	0
International Standard for Analysis of Iron and Steel...	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Formation of Haloids	25	0	0
Action of Light on Dyes	17	10	0
Geological Record	100	0	0
Volcanic Phenomena of Vesuvius	10	0	0
Fossil Phyllopoda	10	0	0
Photographs of Geological Interest	9	5	0
Lias of Northamptonshire ...	25	0	0
Registration of Type-Specimens of British Fossils	5	5	0
Investigation of Elbolton Cave	25	0	0
Botanical Station at Peradeniya	50	0	0
Experiments with a Tow-net	40	0	0
Marine Biological Association	12	10	0
Disappearance of Native Plants	5	0	0
Action of Waves and Currents in Estuaries	125	0	0
Anthropometric Calculations	10	0	0
New Edition of 'Anthropological Notes and Queries'	50	0	0
North-Western Tribes of Canada	200	0	0
Corresponding Societies	25	0	0
	£1,029	10	0

1892.

	£	s.	d.
Observations on Ben Nevis ...	50	0	0
Photographs of Meteorological Phenomena	15	0	0
Pellian Equation Tables	10	0	0
Discharge of Electricity from Points	50	0	0
Seismological Phenomena of Japan	10	0	0
Formation of Haloids	12	0	0
Properties of Solutions	10	0	0
Action of Light on Dyed Colours	10	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	20	0	0
Underground Waters	10	0	0
Investigation of Elbolton Cave	25	0	0
Excavations at Oldbury Hill	10	0	0
Cretaceous Polyzoa	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	17	10	0
Deep-sea Tow-net	40	0	0
Fauna of Sandwich Islands...	100	0	0
Zoology and Botany of West India Islands	100	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Anthropometric Laboratory...	5	0	0
Anthropological Notes and Queries	20	0	0
Prehistoric Remains in Mashonaland	50	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	25	0	0
	£864	10	0

1893.

	£	s.	d.
Electrical Standards	25	0	0
Observations on Ben Nevis ...	150	0	0
Mathematical Tables	15	0	0
Intensity of Solar Radiation	2	8	6
Magnetic Work at the Falmouth Observatory	25	0	0
Isomeric Naphthalene Derivatives	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	5	0	0
Underground Waters	5	0	0
Shell-bearing Deposits at Clava, Chapelhall, &c.	20	0	0
Eurypterids of the Pentland Hills	10	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	30	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	50	0	0

	£	s.	d.
Exploration of Irish Sea	30	0	0
Physiological Action of Oxygen in Asphyxia	20	0	0
Index of Genera and Species of Animals	20	0	0
Exploration of Karakoram Mountains	50	0	0
Scottish Place-names	7	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Economic Training	3	7	0
Anthropometric Laboratory	5	0	0
Exploration in Abyssinia	25	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	30	0	0
	£907	15	6

1894.

	£	s.	d.
Electrical Standards...........	25	0	0
Photographs of Meteorological Phenomena..............	10	0	0
Tables of Mathematical Functions	15	0	0
Intensity of Solar Radiation	5	5	6
Wave-length Tables	10	0	0
Action of Light upon Dyed Colours	5	0	0
Erratic Blocks	15	0	0
Fossil Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	20	0	0
Eurypterids of the Pentland Hills............................	5	0	0
New Sections of Stonesfield Slate	14	0	0
Observations on Earth-tremors	50	0	0
Exploration of Calf-Hole Cave............................	5	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	5	0	0
Zoology of the Sandwich Islands	100	0	0
Zoology of the Irish Sea	40	0	0
Structure and Function of the Mammalian Heart...........	10	0	0
Exploration in Abyssinia ...	30	0	0
Economic Training	9	10	0
Anthropometric Laboratory Statistics........................	5	0	0
Ethnographical Survey	10	0	0
The Lake Village at Glastonbury............................	40	0	0
Anthropometrical Measurements in Schools	5	0	0
Mental and Physical Condition of Children..............	20	0	0
Corresponding Societies	25	0	0
	£583	15	6

1895.

	£	s.	d.
Electrical Standards...........	25	0	0
Photographs of Meteorological Phenomena	10	0	0
Earth Tremors	75	0	0
Abstracts of Physical Papers	100	0	0
Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
Comparison of Magnetic Standards	25	0	0
Meteorological Observations on Ben Nevis	50	0	0
Wave-length Tables of the Spectra of the Elements ...	10	0	0
Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives.........................	30	0	0
Electrolytic Quantitative Analysis	30	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills...........................	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea..............	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut ...	50	0	0
Calibration and Comparison of Measuring Instruments ...	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph..............	25	0	0
Corresponding Societies	30	0	0
	£977	15	5

General Meetings.

On Wednesday, September 11, at 8 P.M., in the Public Hall, Ipswich, the Most Hon. the Marquis of Salisbury, K.G., D.C.L., F.R.S. (represented by the Right Hon. Lord Kelvin, D.C.L., Pres.R.S.) resigned the office of President to Captain Sir Douglas Galton, K.C.B., D.C.L., LL.D., F.R.S., F.R.G.S., F.G.S., who took the Chair, and delivered an Address, for which see page 3.

On Thursday, September 12, at 8.30 P.M., a Soirée took place at the Museum.

On Friday, September 13, at 8.30 P.M., in the Public Hall, Professor Silvanus P. Thompson, F.R.S., delivered a discourse on 'Magnetism in Rotation.'

On Monday, September 16, at 8.30 P.M., in the Public Hall, Professor Percy F. Frankland, F.R.S., delivered a discourse on 'The Work of Pasteur and its Various Developments.'

On Tuesday, September 17, at 8.30 P.M., a Soirée took place at the Museum.

On Wednesday, September 18, at 2.30 P.M., in the Lecture Hall, the concluding General Meeting took place, when the Proceedings of the General Committee and the Grants of Money for Scientific Purposes were explained to the Members.

The Meeting was then adjourned to Liverpool. [The Meeting is appointed to commence on Wednesday, September 16, 1896.]

PRESIDENT'S ADDRESS.

ADDRESS

BY

SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S.,

PRESIDENT.

My first duty is to convey to you, Mr. Mayor, and to the inhabitants of Ipswich, the thanks of the British Association for your hospitable invitation to hold our sixty-fifth meeting in your ancient town, and thus to recall the agreeable memories of the similar favour which your predecessors conferred on the Association forty-four years ago.

In the next place I feel it my duty to say a few words on the great loss which science has recently sustained—the death of the Right Hon. Thomas Henry Huxley. It is unnecessary for me to enlarge, in the presence of so many to whom his personality was known, upon his charm in social and domestic life; but upon the debt which the Association owes to him for the assistance which he rendered in the promotion of science I cannot well be silent. Huxley was preeminently qualified to assist in sweeping away the obstruction by dogmatic authority, which in the early days of the Association fettered progress in certain branches of science. For, whilst he was an eminent leader in biological research, his intellectual power, his original and intrepid mind, his vigorous and masculine English, made him a writer who explained the deepest subject with transparent clearness. And as a speaker his lucid and forcible style was adorned with ample and effective illustration in the lecture-room; and his energy and wealth of argument in a more public arena largely helped to win the battle of evolution, and to secure for us the right to discuss questions of religion and science without fear and without favour.

It may, I think, interest you to learn that Huxley first made the acquaintance of Tyndall at the meeting of the Association held in this town in 1851.

About forty-six years ago I first began to attend the meetings of the British Association; and I was elected one of your general secretaries about twenty-five years ago.

It is not unfitting, therefore, that I should recall to your minds the conditions under which science was pursued at the formation of the Association, as well as the very remarkable position which the Association has occupied in relation to science in this country.

Between the end of the sixteenth century and the early part of the present century several societies had been created to develop various branches of science. Some of these societies were established in London, and others in important provincial centres.

In 1831, in the absence of railways, communication between different parts of the country was slow and difficult. Science was therefore localised; and in addition to the universities in England, Scotland, and Ireland, the towns of Birmingham, Manchester, Plymouth and York each maintained an important nucleus of scientific research.

Origin of the British Association.

Under these social conditions the British Association was founded in September 1831.

The general idea of its formation was derived from a migratory society which had been previously formed in Germany; but whilst the German society met for the special occasion on which it was summoned, and then dissolved, the basis of the British Association was continuity.

The objects of the founders of the British Association were enunciated in their earliest rules to be:—

'To give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivated science in different parts of the British Empire with one another, and with foreign philosophers; to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impede its progress.'

Thus the British Association for the Advancement of Science based its utility upon the opportunity it afforded for combination.

The first meeting of the Association was held at York with 353 members.

As an evidence of the want which the Association supplied, it may be mentioned that at the second meeting, which was held at Oxford, the number of members was 435. The third meeting, at Cambridge, numbered over 900 members, and at the meeting at Edinburgh in 1834 there were present 1,298 members.

At its third meeting, which was held at Cambridge in 1833, the Association, through the influence it had already acquired, induced the

Government to grant a sum of 500*l.* for the reduction of the astronomical observations of Baily. And at the same meeting the General Committee commenced to appropriate to scientific research the surplus from the subscriptions of its members. The committees on each branch of science were desired 'to select definite and important objects of science, which they may think most fit to be advanced by an application of the funds of the society, either in compensation for labour, or in defraying the expense of apparatus, or otherwise, stating their reasons for their selection, and, when they may think proper, designating individuals to undertake the desired investigations.'

The several proposals were submitted to the Committee of Recommendations, whose approval was necessary before they could be passed by the General Committee. The regulations then laid down still guide the Association in the distribution of its grants. At that early meeting the Association was enabled to apply 600*l.* to these objects.

I have always wondered at the foresight of the framers of the constitution of the British Association, the most remarkable feature of which is the lightness of the tie which holds it together. It is not bound by any complex central organisation. It consists of a federation of Sections, whose youth and energy are yearly renewed by a succession of presidents and vice-presidents, whilst in each Section some continuity of action is secured by the less movable secretaries.

The governing body is the General Committee, the members of which are selected for their scientific work ; but their controlling power is tempered by the law that all changes of rules, or of constitution, should be submitted to, and receive the approval of, the Committee of Recommendations. This committee may be described as an ideal Second Chamber. It consists of the most experienced members of the Association.

The administration of the Association in the interval between annual meetings is carried on by the Council, an executive body, whose duty it is to complete the work of the annual meeting (*a*) by the publication of its proceedings ; (*b*) by giving effect to resolutions passed by the General Committee; (*c*) it also appoints the Local Committee and organises the *personnel* of each Section for the next meeting.

I believe that one of the secrets of the long-continued success and vitality of the British Association lies in this purely democratic constitution, combined with the compulsory careful consideration which must be given to suggested organic changes.

The Association is now in the sixty-fifth year of its existence. In its origin it invited the philosophical societies dispersed throughout Great Britain to unite in a co-operative union.

Within recent years it has endeavoured to consolidate that union.

At the present time almost all important local scientific societies scattered throughout the country, some sixty-six in number, are in correspondence with the Association. Their delegates hold annual conferences at our meetings. The Association has thus extended the sphere of its action:

it places the members of the local societies engaged in scientific work in relation with each other, and brings them into co-operation with members of the Association and with others engaged in original investigations, and the papers which the individual societies publish annually are catalogued in our Report. Thus by degrees a national catalogue will be formed of the scientific work of these societies.

The Association has, moreover, shown that its scope is coterminous with the British Empire by holding one of its annual meetings at Montreal, and we are likely soon to hold a meeting in Toronto.

Condition of certain Sciences at the formation of the British Association.

The Association, at its first meeting, began its work by initiating a series of reports upon the then condition of the several sciences.

A rapid glance at some of these reports will not only show the enormous strides which have been made since 1831 in the investigation of facts to elucidate the laws of Nature, but it may afford a slight insight into the impediments offered to the progress of investigation by the mental condition of the community, which had been for so long satisfied to accept assumptions without undergoing the labour of testing their truth by ascertaining the real facts. This habit of mind may be illustrated by two instances selected from the early reports made to the Association. The first is afforded by the report made in 1832, by Mr. Lubbock, on 'Tides.'

This was a subject necessarily of importance to England as a dominant power at sea. But in England records of the tides had only recently been commenced at the dockyards of Woolwich, Sheerness, Portsmouth, and Plymouth, on the request of the Royal Society, and no information had been collected upon the tides on the coasts of Scotland and Ireland.

The British Association may feel pride in the fact that within three years of its inception, viz. by 1834, it had induced the Corporation of Liverpool to establish two tide gauges, and the Government to undertake tidal observations at 500 stations on the coasts of Britain.

Another cognate instance is exemplified by a paper read at the second meeting, in 1832, upon the State of Naval Architecture in Great Britain. The author contrasts the extreme perfection of the carpentry of the internal fittings of the vessels with the remarkable deficiency of mathematical theory in the adjustment of the external form of vessels, and suggests the benefit of the application of refined analysis to the various practical problems which ought to interest shipbuilders—problems of capacity, of displacement, of stowage, of velocity, of pitching and rolling, of masting, of the effects of sails and of the resistance of fluids; and, moreover, suggests that large-scale experiments should be made by Government, to afford the necessary data for calculation.

Indeed, when we consider how completely the whole habit of mind of the populations of the Western world has been changed, since the beginning of the century, from willing acceptance of authority as a rule of life to a universal spirit of inquiry and experimental investigation, is it not probable that this rapid change has arisen from society having been stirred to its foundations by the causes and consequences of the French Revolution?

One of the earliest practical results of this awakening in France was the conviction that the basis of scientific research lay in the accuracy of the standards by which observations could be compared; and the following principles were laid down as a basis for their measurements of length, weight, and capacity: viz. (1) that the unit of linear measure applied to matter in its three forms of extension, viz., length, breadth, and thickness, should be the standard of measures of length, surface, and solidity; (2) that the cubic contents of the linear measure in decimetres of pure water at the temperature of its greatest density should furnish at once the standard weight and the measure of capacity.[1] The metric system did not come into full operation in France till 1840; and it is now adopted by all countries on the continent of Europe except Russia.

The standards of length which were accessible in Great Britain at the formation of the Association were the Parliamentary standard yard lodged in the Houses of Parliament (which was destroyed in 1834 in the fire which burned the Houses of Parliament); the Royal Astronomical Society's standard; and the 10-foot bar of the Ordnance Survey.

The first two were assumed to afford exact measurements at a given temperature. The Ordnance bar was formed of two bars on the principle of a compensating pendulum, and afforded measurements independent of temperature. Standard bars were also disseminated throughout the country, in possession of the corporations of various towns.

The British Association early recognised the importance of uniformity in the record of scientific facts, as well as the necessity for an easy method of comparing standards and for verifying differences between instruments and apparatus required by various observers pursuing similar lines of investigation. At its meeting at Edinburgh in 1834 it caused a comparison to be made between the standard bar at Aberdeen, constructed by Troughton, and the standard of the Royal Astronomical Society, and reported that the scale 'was exceedingly well finished; it was about $\frac{1}{500}$th of an inch shorter than the 5-feet of the Royal Astronomical Society's scale, but it was evident that a great number of minute, yet important, circumstances have hitherto been neglected in the formation of such scales, without an attention to which they cannot be expected to accord with that degree of accuracy which the present state of science demands.' Subsequently, at the meeting at Newcastle in 1863, the Association appointed a committee to report on the best means of providing for a uniformity of weights and measures with reference to the

[1] The litre is the volume of a kilogramme of pure water at its maximum density, and is slightly less than the litre was intended to be, viz., one cubic decimetre. The weight of a cubic decimetre of pure water is 1·000013 kilogrammes.

interests of science. This committee recommended the metric decimal system—a recommendation which has been endorsed by a committee of the House of Commons in the last session of Parliament.

British instrument-makers had been long conspicuous for accuracy of workmanship. Indeed, in the eighteenth century practical astronomy had been mainly in the hands of British observers; for although the mathematicians of France and other countries on the continent of Europe were occupying the foremost place in mathematical investigation, means of astronomical observation had been furnished almost exclusively by English artisans.

The sectors, quadrants, and circles of Ramsden, Bird, and Cary were inimitable by Continental workmen.

But the accuracy of the mathematical-instrument maker had not penetrated into the engineer's workshop. And the foundation of the British Association was coincident with a rapid development of mechanical appliances.

At that time a good workman had done well if the shaft he was turning, or the cylinder he was boring, 'was right to the $\frac{1}{32}$nd of an inch.' This was, in fact, a degree of accuracy as fine as the eye could usually distinguish.

Few mechanics had any distinct knowledge of the method to be pursued for obtaining accuracy; nor, indeed, had practical men sufficiently appreciated either the immense importance or the comparative facility of its acquisition.

The accuracy of workmanship essential to this development of mechanical progress required very precise measurements of length, to which reference could be easily made. No such standards were then available for the workshops. But a little before 1830 a young workman named Joseph Whitworth realised that the basis of accuracy in machinery was the making of a true plane. The idea occurred to him that this could only be secured by making three independent plane surfaces; if each of these would lift the other, they must be planes, and they must be true.

The true plane rendered possible a degree of accuracy beyond the wildest dreams of his contemporaries in the construction of the lathe and the planing machine, which are used in the manufacture of all tools.

His next step was to introduce an exact system of measurement, generally applicable in the workshop.

Whitworth felt that the eye was altogether inadequate to secure this, and appealed to the sense of touch for affording a means of comparison. If two plugs be made to fit into a round hole, they may differ in size by a quantity imperceptible to the eye, or to any ordinary process of measurement, but in fitting them into the hole the difference between the larger and the smaller is felt immediately by the greater ease with which the smaller one fits. In this way a child can tell which is the larger of two cylinders differing in thickness by no more than $\frac{1}{5000}$th of an inch.

Standard gauges, consisting of hollow cylinders with plugs to fit, but differing in diameter by the $\frac{1}{10000}$th or the $\frac{1}{10000}$th of an inch, were given to his workmen, with the result that a degree of accuracy inconceivable to the ordinary mind became the rule of the shop.

To render the construction of accurate gauges possible Whitworth devised his measuring machine, in which the movement was effected by a screw; by this means the distance between two true planes might be measured to the one-millionth of an inch.

These advances in precision of measurement have enabled the degree of accuracy which was formerly limited to the mathematical-instrument maker to become the common property of every machine shop. And not only is the latest form of steam-engine, in the accuracy of its workmanship, little behind the chronometer of the early part of the century, but the accuracy in the construction of experimental apparatus which has thus been introduced has rendered possible recent advances in many lines of research.

Lord Kelvin said in his Presidential Address at Edinburgh, 'Nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient, long-continued labour in the sifting of numerical results.' The discovery of argon, for which Lord Rayleigh and Professor Ramsay have been awarded the Hodgkin prize by the Smithsonian Institution, affords a remarkable illustration of the truth of this remark. Indeed, the provision of accurate standards not only of length, but of weight, capacity, temperature, force, and energy, are amongst the foundations of scientific investigation.

In 1842 the British Association obtained the opportunity of extending its usefulness in this direction.

In that year the Government gave up the Royal Observatory at Kew, and offered it to the Royal Society, who declined it. But the British Association accepted the charge. Their first object was to continue Sabine's valuable observations upon the vibrations of a pendulum in various gases, and to promote pendulum observations in various parts of the world. They subsequently extended it into an observatory for comparing and verifying the various instruments which recent discoveries in physical science had suggested for continuous meteorological and magnetic observations, for observations and experiments on atmospheric electricity, and for the study of solar physics.

This new departure afforded a means for ascertaining the advantages and disadvantages of the several varieties of scientific instruments; as well as for standardising and testing instruments, not only for instrument-makers, but especially for observers by whom simultaneous observations were then being carried on in different parts of the world; and also for training observers proceeding abroad on scientific expeditions.

Its special object was to promote original research, and expenditure was not to be incurred on apparatus merely intended to exhibit the necessary consequences of known laws.

The rapid strides in electrical science had attracted attention to the measurement of electrical resistances, and in 1859 the British Association appointed a special committee to devise a standard. The standard of resistance proposed by that committee became the generally accepted standard, until the requirements of that advancing science led to the adoption of an international standard.

In 1866 the Meteorological Department of the Board of Trade entered into close relations with the Kew Observatory.

And in 1871 Mr. Gassiot transferred 10,000*l.* upon trust to the Royal Society for the maintenance of the Kew Observatory, for the purpose of assisting in carrying on magnetical, meteorological, and other physical observations. The British Association thereupon, after having maintained this Observatory for nearly thirty years, at a total expenditure of about 12,000*l.*, handed the Observatory over to the Royal Society.

The 'Transactions' of the British Association are a catalogue of its efforts in every branch of science, both to promote experimental research and to facilitate the application of the results to the practical uses of life.

But probably the marvellous development in science which has accompanied the life-history of the Association will be best appreciated by a brief allusion to the condition of some of the branches of science in 1831 as compared with their present state.

Geological and Geographical Science.

Geology.

At the foundation of the Association geology was assuming a prominent position in science. The main features of English geology had been illustrated as far back as 1821, and, among the founders of the British Association, Murchison and Phillips, Buckland, Sedgwick and Conybeare, Lyell and De la Beche, were occupied in investigating the data necessary for perfecting a geological chronology by the detailed observations of the various British deposits, and by their co-relation with the Continental strata. They were thus preparing the way for those large generalisations which have raised geology to the rank of an inductive science.

In 1831 the Ordnance maps published for the southern counties had enabled the Government to recognise the importance of a geological survey by the appointment of Mr. De la Beche to affix geological colours to the maps of Devonshire and portions of Somerset, Dorset and Cornwall; and in 1835 Lyell, Buckland and Sedgwick induced the Government to establish the Geological Survey Department, not only for promoting geological science, but on account of its practical bearing on agriculture, mining, the making of roads, railways and canals, and on other branches of national industry.

Geography.

The Ordnance Survey appears to have had its origin in a proposal of the French Government to make a joint-measurement of an arc of the meridian. This proposal fell through at the outbreak of the Revolution; but the measurement of the base for that object was taken as a foundation for a national survey. In 1831, however, the Ordnance Survey had only published the 1-inch map for the southern portion of England, and the great triangulation of the kingdom was still incomplete.

In 1834 the British Association urged upon the Government that the advancement of various branches of science was greatly retarded by the want of an accurate map of the whole of the British Isles; and that, consequently, the engineer and the meteorologist, the agriculturist and the geologist, were each fettered in their scientific investigations by the absence of those accurate data which now lie ready to his hand for the measurement of length, of surface, and of altitude.

Yet the first decade of the British Association was coincident with a considerable development of geographical research. The Association was persistent in pressing on the Government the scientific importance of sending the expedition of Ross to the Antarctic and of Franklin to the Arctic regions. We may trust that we are approaching a solution of the geography of the North Pole; but the Antarctic regions still present a field for the researches of the meteorologist, the geologist, the biologist, and the magnetic observer, which the recent voyage of M. Borchgrevink leads us to hope may not long remain unexplored.

In the same decade the question of an alternative route to India by means of a communication between the Mediterranean and the Persian Gulf was also receiving attention, and in 1835 the Government employed Colonel Chesney to make a survey of the Euphrates valley in order to ascertain whether that river would enable a practicable route to be formed from Iskanderoon, or Tripoli, opposite Cyprus, to the Persian Gulf. His valuable surveys are not, however, on a sufficiently extensive scale to enable an opinion to be formed as to whether a navigable waterway through Asia Minor is physically practicable, or whether the cost of establishing it might not be prohibitive.

The advances of Russia in Central Asia have made it imperative to provide an easy, rapid, and alternative line of communication with our Eastern possessions, so as not to be dependent upon the Suez Canal in time of war. If a navigation cannot be established, a railway between the Mediterranean and the Persian Gulf has been shown by the recent investigations of Messrs. Hawkshaw and Hayter, following on those of others, to be perfectly practicable and easy of accomplishment; such an undertaking would not only be of strategical value, but it is believed it would be commercially remunerative.

Speke and Grant brought before the Association, at its meeting at Newcastle in 1863, their solution of the mystery of the Nile basin, which had puzzled geographers from the days of Herodotus; and the efforts of Livingstone and Stanley and others have opened out to us the interior of Africa. I cannot refrain here from expressing the deep regret which geologists and geographers, and indeed all who are interested in the progress of discovery, feel at the recent death of Joseph Thomson. His extensive, accurate, and trustworthy observations added much to our knowledge of Africa, and by his premature death we have lost one of its most competent explorers.

Chemical, Astronomical and Physical Science.

Chemistry.

The report made to the Association on the state of the chemical sciences in 1832, says that the efforts of investigators were then being directed to determining with accuracy the true nature of the substances which compose the various products of the organic and inorganic kingdoms, and the exact ratios by weight which the different constituents of these substances bear to each other.

But since that day the science of chemistry has far extended its boundaries. The barrier has vanished which was supposed to separate the products of living organisms from the substances of which minerals consist, or which could be formed in the laboratory. The number of distinct carbon compounds obtainable from organisms has greatly increased; but it is small when compared with the number of such compounds which have been artificially formed. The methods of analysis have been perfected. The physical, and especially the optical, properties of the various forms of matter have been closely studied, and many fruitful generalisations have been made. The form in which these generalisations would now be stated may probably change, some, perhaps, by the overthrow or disuse of an ingenious guess at Nature's workings, but more by that change which is the ordinary growth of science—namely, inclusion in some simpler and more general view.

In these advances the chemist has called the spectroscope to his aid. Indeed, the existence of the British Association has been practically coterminous with the comparatively newly developed science of spectrum analysis, for though Newton,[1] Wollaston, Fraunhofer, and Fox Talbot had worked at the subject long ago, it was not till Kirchhoff and Bunsen set a seal on the prior labours of Stokes, Ångström, and Balfour Stewart that the spectra of terrestrial elements have been mapped out and grouped; that by its help new elements have been discovered, and that the idea has been suggested that the various orders of spectra of the same

[1] Joannes Marcus Marci, of Kroniand in Bohemia, was the only predecessor of Newton who had any knowledge of the formation of a spectrum by a prism. He not only observed that the coloured rays diverged as they left the prism, but that a coloured ray did not change in colour after transmission through a prism. His book, *Thaumantias, liber de arcu cœlesti deque colorum apparentium natura*, Prag, 1648, was, however, not known to Newton, and had no influence upon future discoveries.

element are due to the existence of the element in different molecular forms—allotropic or otherwise—at different temperatures.

But great as have been the advances of terrestrial chemistry through its assistance, the most stupendous advance which we owe to the spectroscope lies in the celestial direction.

Astronomy.

At the third meeting of the Association, at Cambridge, in 1833, Dr. Whewell said that astronomy is not only the queen of science, but the only perfect science, which was 'in so elevated a state of flourishing maturity that all that remained was to determine with the extreme of accuracy the consequences of its rules by the profoundest combinations of mathematics; the magnitude of its data by the minutest scrupulousness of observation.' But in the previous year, Airy, in his report to the Association on the progress of Astronomy, had pointed out that the observations of the planet Uranus could not be united in one elliptic orbit; a remark which turned the attention of Adams to the discovery of Neptune.

In his report on the recent progress of Optics, Brewster in 1832 suggested that with the assistance of adequate instruments 'it would be possible to study the action of the elements of material bodies upon rays of artificial light, and thereby to discover the analogies between their affinities and those which produce the fixed lines in the spectra of the stars; and thus to study the effects of the combustions which light up the suns of other systems.'

This idea has now been realised. All the stars which shine brightly enough to impress an image of the spectrum upon a photographic plate have been classified on a chemical basis. The close connection between stars and nebulæ has been demonstrated; and while the modern science of thermodynamics has shown that the hypothesis of Kant and Laplace on stellar formation, so far as it assumed a fiery cloud for the beginning, is no longer tenable, but that in all probability it gives the true explanation of stellar evolution, if for the fiery cloud we substitute cold meteoric particles, as suggested by Waterston[1] and by Lord Kelvin[2] at the Liverpool meeting of the British Association in 1854.

We now know that the spectra of many of the terrestrial elements in the chromosphere of the sun differ from those familiar to us in our laboratories. We begin to glean the fact that the chromospheric spectra are similar to those indicated by the absorption going on in the hottest stars, and Lockyer has not hesitated to affirm that these facts would indicate that in those localities we are in the presence of the actions of temperatures suffi-

[1] In Note L on a paper on 'The Physics of Media,' communicated to the Royal Society, December 11, 1845, read March 5, 1846, and published, in 1892, in the *Transactions*, with an introduction by Lord Rayleigh.

[2] *Brit. Assoc. Report*, 1854, Pt. II., pp. 59–63; *Mathematical and Physical Papers*, vol. ii., art. lxix., p. 40.

ciently high to break up our chemical elements into finer forms. Other students of these phenomena may not agree in this view, and possibly the discrepancies may be due to default in our terrestrial chemistry. Still, I would recall to you that Dr. Carpenter, in his Presidential Address at Brighton in 1872, almost censured the speculations of Frankland and Lockyer in 1868 for attributing a certain bright line in the spectrum of solar prominences (which was not identifiable with that of any known terrestrial source of light) to a hypothetical new substance which they proposed to call 'helium,' because 'it had not received that verification which, in the case of Crookes' search for thallium, was afforded by the actual discovery of the new metal.' Ramsay has now shown that this gas is present in dense minerals on earth; but we have now also learned from Lockyer that it and other associated gases are not only found with hydrogen in the solar chromosphere, but that these gases, with hydrogen, form a large percentage of the atmospheric constituents of some of the hottest stars in the heavens.

The spectroscope has also made us acquainted with the motions and even the velocities of those distant orbs which make up the sidereal universe. It has enabled us to determine that many stars, single to the eye, are really double, and many of the conditions of these strange systems have been revealed. The rate at which matter is moving in solar cyclones and winds is now familiar to us. And I may also add that quite recently this wonderful instrument has enabled Professor Keeler to verify Clerk-Maxwell's theory that the rings of Saturn consist of a marvellous company of separate moons—as it were, a cohort of courtiers revolving round their queen—with velocities proportioned to their distances from the planet.

Physics

If we turn to the sciences which are included under physics, the progress has been equally marked.

In optical science, in 1831 the theory of emission as contrasted with the undulatory theory of light was still under discussion.

Young, who was the first to explain the phenomena due to the interference of the rays of light as a consequence of the theory of waves, and Fresnel, who showed the intensity of light for any relative position of the interference-waves, both had only recently passed away.

The investigations into the laws which regulate the conduction and radiation of heat, together with the doctrine of latent and of specific heat, and the relations of vapour to air, had all tended to the conception of a material heat, or caloric, communicated by an actual flow and emission.

It was not till 1834 that improved thermometrical appliances had enabled Forbes and Melloni to establish the polarisation of heat, and thus to lay the foundation of an undulatory theory for heat similar to that which was in progress of acceptation for light.

Whewell's report, in 1832, on magnetism and electricity shows that these branches of science were looked upon as cognate, and that the theory of two opposite electric fluids was generally accepted.

In magnetism, the investigations of Hansteen, Gauss, and Weber in Europe, and the observations made under the Imperial Academy of Russia over the vast extent of that empire, had established the existence of magnetic poles, and had shown that magnetic disturbances were simultaneous at all the stations of observation.

At their third meeting the Association urged the Government to establish magnetic and meteorological observatories in Great Britain and her colonies and dependencies in different parts of the earth, furnished with proper instruments, constructed on uniform principles, and with provisions for continued observations at those places.

In 1839 the British Association had a large share in inducing the Government to initiate the valuable series of experiments for determining the intensity, the declination, the dip, and the periodical variations of the magnetic needle which were carried on for several years, at numerous selected stations over the surface of the globe, under the directions of Sabine and Lefroy.

In England systematic and regular observations are still made at Greenwich, Kew, and Stonyhurst. For some years past similar observations by both absolute and self-recording instruments have also been made at Falmouth—close to the home of Robert Were Fox, whose name is inseparably connected with the early history of terrestrial magnetism in this country—but under such great financial difficulties that the continuance of the work is seriously jeopardised. It is to be hoped that means may be forthcoming to carry it on. Cornishmen, indeed, could found no more fitting memorial of their distinguished countryman, John Couch Adams, than by suitably endowing the magnetic observatory in which he took so lively an interest.

Far more extended observation will be needed before we can hope to have an established theory as to the magnetism of the earth. We are without magnetic observations over a large part of the Southern Hemisphere. And Professor Rücker's recent investigations tell us that the earth seems as it were alive with magnetic forces, be they due to electric currents or to variations in the state of magnetised matter; that the disturbances affect not only the diurnal movement of the magnet, but that even the small part of the secular change which has been observed, and which has taken centuries to accomplish, is interfered with by some slower agency. And, what is more important, he tells us that none of these observations stand as yet upon a firm basis, because standard instruments have not been in accord; and much labour, beyond the power of individual effort, has hitherto been required to ascertain whether the relations between them are constant or variable.

In electricity, in 1831, just at the time when the British Association was founded, Faraday's splendid researches in electricity and magnetism at the Royal Institution had begun with his discovery of magneto-electric induction, his investigation of the laws of electro-chemical decomposition, and of the mode of electrolytical action.

But, the practical application of our electrical knowledge was then limited to the use of lightning-conductors for buildings and ships. Indeed, it may be said that the applications of electricity to the use of man have grown up side by side with the British Association.

One of the first practical applications of Faraday's discoveries was in the deposition of metals and electro-plating, which has developed into a large branch of national industry; and the dissociating effect of the electric arc, for the reduction of ores, and in other processes, is daily obtaining a wider extension.

But probably the application of electricity which is tending to produce the greatest change in our mental, and even material condition, is the electric telegraph and its sister, the telephone. By their agency not only do we learn, almost at the time of their occurrence, the events which are happening in distant parts of the world, but they are establishing a community of thought and feeling between all the nations of the world which is influencing their attitude towards each other, and, we may hope, may tend to weld them more and more into one family.

The electric telegraph was introduced experimentally in Germany in 1833, two years after the formation of the Association. It was made a commercial success by Cooke and Wheatstone in England, whose first attempts at telegraphy were made on the line from Euston to Camden Town in 1837, and on the line from Paddington to West Drayton in 1838.

The submarine telegraph to America, conceived in 1856, became a practical reality in 1861 through the commercial energy of Cyrus Field and Pender, aided by the mechanical skill of Latimer Clark, Gooch, and others, and the scientific genius of Lord Kelvin. The knowledge of electricity gained by means of its application to the telegraph largely assisted the extension of its utility in other directions.

The electric light gives, in its incandescent form, a very perfect hygienic light. Where rivers are at hand the electrical transmission of power will drive railway trains and factories economically, and might enable each artisan to convert his room into a workshop, and thus assist in restoring to the labouring man some of the individuality which the factory has tended to destroy.

In 1843 Joule described his experiments for determining the mechanical equivalent of heat. But it was not until the meeting at Oxford, in 1847, that he fully developed the law of the conservation of energy, which, in conjunction with Newton's law of the conservation of momentum, and Dalton's law of the conservation of chemical elements, constitutes a complete mechanical foundation for physical science.

Who, at the foundation of the Association, would have believed some far-seeing philosopher if he had foretold that the spectroscope would analyse the constituents of the sun and measure the motions of the stars; that we should liquefy air and utilise temperatures approaching to the absolute zero for experimental research; that, like the magician in the 'Arabian Nights,' we should annihilate distance by means of the electric telegraph and the telephone; that we should illuminate our largest buildings instantaneously, with the clearness of day, by means of the electric current; that by the electric transmission of power we should be able to utilise the Falls of Niagara to work factories at distant places; that we should extract metals from the crust of the earth by the same electrical agency to which, in some cases, their deposition has been attributed?

These discoveries and their applications have been brought to their present condition by the researches of a long line of scientific explorers, such as Dalton, Joule, Maxwell, Helmholtz, Herz, Kelvin, and Rayleigh, aided by vast strides made in mechanical skill. But what will our successors be discussing sixty years hence? How little do we yet know of the vibrations which communicate light and heat! Far as we have advanced in the application of electricity to the uses of life, we know but little even yet of its real nature. We are only on the threshold of the knowledge of molecular action, or of the constitution of the all-pervading æther. Newton, at the end of the seventeenth century, in his preface to the 'Principia,' says: 'I have deduced the motions of the planets by mathematical reasoning from forces; and I would that we could derive the other phenomena of Nature from mechanical principles by the same mode of reasoning. For many things move me, so that I somewhat suspect that all such may depend on certain forces by which the particles of bodies, through causes not yet known, are either urged towards each other according to regular figures, or are repelled and recede from each other; and these forces being unknown, philosophers have hitherto made their attempts on Nature in vain.'

In 1848 Faraday remarked: 'How rapidly the knowledge of molecular forces grows upon us, and how strikingly every investigation tends to develop more and more their importance!

'A few years ago magnetism was an occult force, affecting only a few bodies; now it is found to influence all bodies, and to possess the most intimate relation with electricity, heat, chemical action, light, crystallisation; and through it the forces concerned in cohesion. We may feel encouraged to continuous labours, hoping to bring it into a bond of union with gravity itself.'

But it is only within the last few years that we have begun to realise that electricity is closely connected with the vibrations which cause heat and light, and which seem to pervade all space—vibrations which may be termed the voice of the Creator calling to each atom and to each cell of protoplasm to fall into its ordained position, each, as it were, a musical note in the harmonious symphony which we call the universe.

Meteorology.

At the first meeting, in 1831, Professor James D. Forbes was requested to draw up a report on the State of Meteorological Science, on the ground that this science is more in want than any other of that systematic direction which it is one great object of the Association to give.

Professor Forbes made his first report in 1832, and a subsequent report in 1840. The systematic records now kept in various parts of the world of barometric pressure, of solar heat, of the temperature and physical conditions of the atmosphere at various altitudes, of the heat of the ground at various depths, of the rainfall, of the prevalence of winds, and the gradual elucidation not only of the laws which regulate the movements of cyclones and storms, but of the influences which are exercised by the sun and by electricity and magnetism, not only upon atmospheric conditions, but upon health and vitality, are gradually approximating meteorology to the position of an exact science.

England took the lead in rainfall observations. Mr. G. J. Symons organised the British Rainfall System in 1860 with 178 observers, a system which until 1876 received the help of the British Association. Now Mr. Symons himself conducts it, assisted by more than 3,000 observers, and these volunteers not only make the observations, but defray the expense of their reduction and publication. In foreign countries this work is done by Government officers at the public cost.

At the present time a very large number of rain gauges are in daily use throughout the world. The British Islands have more than 3,000, and India and the United States have nearly as many; France and Germany are not far behind; Australia probably has more—indeed, one colony alone, New South Wales, has more than 1,100.

The storm warnings now issued under the excellent systematic organisation of the Meteorological Committee may be said to have had their origin in the terrible storm which broke over the Black Sea during the Crimean War, on November 27, 1855. Leverrier traced the progress of that storm, and seeing how its path could have been reported in advance by the electric telegraph, he proposed to establish observing stations which should report to the coasts the probability of the occurrence of a storm. Leverrier communicated with Airy, and the Government authorised Admiral FitzRoy to make tentative arrangements in this country. The idea was also adopted on the Continent, and now there are few civilised countries north or south of the equator without a system of storm warning.[1]

[1] It has often been supposed that Leverrier was also the first to issue a daily weather map, but that was not the case, for in the Great Exhibition of 1851 the Electric Telegraph Company sold daily weather maps, copies of which are still in existence, and the data for them were, it is believed, obtained by Mr. James Glaisher, F.R.S., at that time Superintendent of the Meteorological Department at Greenwich.

Biological Science.

Botany.

The earliest Reports of the Association which bear on the biological sciences were those relating to botany.

In 1831 the controversy was yet unsettled between the advantages of the Linnean, or Artificial system, as contrasted with the Natural system of classification. Histology, morphology, and physiological botany, even if born, were in their early infancy.

Our records show that von Mohl noted cell division in 1835, the presence of chlorophyll corpuscles in 1837; and he first described protoplasm in 1846.

Vast as have been the advances of physiological botany since that time, much of its fundamental principles remain to be worked out, and I trust that the establishment, for the first time, of a permanent Section for botany at the present meeting will lead the Association to take a more prominent part than it has hitherto done in the further development of this branch of biological science.

Animal Physiology.

In 1831 Cuvier, who during the previous generation had, by the collation of facts followed by careful inductive reasoning, established the plan on which each animal is constructed, was approaching the termination of his long and useful life. He died in 1832; but in 1831 Richard Owen was just commencing his anatomical investigations and his brilliant contributions to palæontology.

The impulse which their labours gave to biological science was reflected in numerous reports and communications, by Owen and others, throughout the early decades of the British Association, until Darwin propounded a theory of evolution which commanded the general assent of the scientific world. For this theory was not absolutely new. But just as Cuvier had shown that each bone in the fabric of an animal affords a clue to the shape and structure of the animal, so Darwin brought harmony into scattered facts, and led us to perceive that the moulding hand of the Creator may have evolved the complicated structures of the organic world from one or more primeval cells.

Richard Owen did not accept Darwin's theory of evolution, and a large section of the public contested it. I well remember the storm it produced—a storm of praise by my geological colleagues, who accepted the result of investigated facts; a storm of indignation such as that which would have burned Galileo at the stake from those who were not yet prepared to question the old authorities; but they diminish daily.

We are, however, as yet only on the threshold of the doctrine of evolution. Does not each fresh investigation, even into the embryonic stage of the simpler forms of life, suggest fresh problems?

Anthropology.

The impulse given by Darwin has been fruitful in leading others to consider whether the same principle of evolution may not have governed the moral as well as the material progress of the human race. Mr. Kidd tells us that nature as interpreted by the struggle for life contains no sanction for the moral progress of the individual, and points out that if each of us were allowed by the conditions of life to follow his own inclination, the average of each generation would distinctly deteriorate from that of the preceding one ; but because the law of life is ceaseless and inevitable struggle and competition, ceaseless and inevitable selection and rejection, the result is necessarily ceaseless and inevitable progress. Evolution, as Sir William Flower said, is the message which biology has sent to help us on with some of the problems of human life, and Francis Galton urges that man, the foremost outcome of the awful mystery of evolution, should realise that he has the power of shaping the course of future humanity by using his intelligence to discover and expedite the changes which are necessary to adapt circumstances to man, and man to circumstances.

In considering the evolution of the human race, the science of preventive medicine may afford us some indication of the direction in which to seek for social improvement. One of the early steps towards establishing that science upon a secure basis was taken in 1835 by the British Association, who urged upon the Government the necessity of establishing registers of mortality showing the causes of death 'on one uniform plan in all parts of the King's dominions, as the only means by which general laws touching the influence of causes of disease and death could be satisfactorily deduced.' The general registration of births and deaths was commenced in 1838. But a mere record of death and its proximate cause is insufficient. Preventive medicine requires a knowledge of the details of the previous conditions of life and of occupation. Moreover, death is not our only or most dangerous enemy, and the main object of preventive medicine is to ward off disease. Disease of body lowers our useful energy. Disease of body or of mind may stamp its curse on succeeding generations.

The anthropometric laboratory affords to the student of anthropology a means of analysing the causes of weakness, not only in bodily, but also in mental life.

Mental actions are indicated by movements and their results. Such signs are capable of record, and modern physiology has shown that bodily movements correspond to action in nerve-centres, as surely as the motions of the telegraph-indicator express the movements of the operator's hands in the distant office.

Thus there is a relation between a defective status in brain power and defects in the proportioning of the body. Defects in physiognomical details, too finely graded to be measured with instruments, may be appreciated with accuracy by the senses of the observer ; and the records show that these defects are, in a large degree, associated with a brain status lower than the average in mental power.

A report presented by one of your committees gives the results of observations made on 100,000 school-children examined individually in order to determine their mental and physical condition for the purpose of classification. This shows that about 16 per 1,000 of the elementary school population appear to be so far defective in their bodily or brain condition as to need special training to enable them to undertake the duties of life, and to keep them from pauperism or crime.

Many of our feeble-minded children, and much disease and vice, are the outcome of inherited proclivities. Francis Galton has shown us that types of criminals which have been bred true to their kind are one of the saddest disfigurements of modern civilisation; and he says that few deserve better of their country than those who determine to lead celibate lives through a reasonable conviction that their issue would probably be less fitted than the generality to play their part as citizens.

These considerations point to the importance of preventing those suffering from transmissible disease, or the criminal, or the lunatic, from adding fresh sufferers to the teeming misery in our large towns. And in any case, knowing as we do the influence of environment on the development of individuals, they point to the necessity of removing those who are born with feeble minds, or under conditions of moral danger, from surrounding deteriorating influences.

These are problems which materially affect the progress of the human race, and we may feel sure that, as we gradually approach their solution, we shall more certainly realise that the theory of evolution, which the genius of Darwin impressed on this century, is but the first step on a biological ladder which may possibly eventually lead us to understand how in the drama of creation man has been evolved as the highest work of the Creator.

Bacteriology.

The sciences of medicine and surgery were largely represented in the earlier meetings of the Association, before the creation of the British Medical Association afforded a field for their more intimate discussion. The close connection between the different branches of science is causing a revival in our proceedings of discussions on some of the highest medical problems, especially those relating to the spread of infectious and epidemic disease.

It is interesting to contrast the opinion prevalent at the foundation of the Association with the present position of the question.

A report to the Association in 1834, by Professor Henry, on contagion, says:—

'The notion that contagious emanations are at all connected with the diffusion of animalculæ through the atmosphere is at variance with all that is known of the diffusion of volatile contagion.'

Whilst it had long been known that filthy conditions in air, earth and water fostered fever, cholera, and many other forms of disease, and that the disease ceased to spread on the removal of these conditions, yet the reason for their propagation or diminution remained under a veil.

Leeuwenhoek in 1680 described the yeast-cells, but Schwann in 1837 first showed clearly that fermentation was due to the activity of the yeast-cells; and, although vague ideas of fermentation had been current during the past century, he laid the foundation of our exact knowledge of the nature of the action of ferments, both organised and unorganised. It was not until 1860, after the prize of the Academy of Sciences had been awarded to Pasteur for his essay against the theory of spontaneous generation, that his investigations into the action of ferments[1] enabled him to show that the effects of the yeast-cell are indissolubly bound up with the activities of the cell as a living organism, and that certain diseases, at least, are due to the action of ferments in the living being. In 1865 he showed that the disease of silkworms, which was then undermining the silk industry in France, could be successfully combated. His further researches into anthrax, fowl cholera, swine fever, rabies, and other diseases proved the theory that those diseases are connected in some way with the introduction of a microbe into the body of an animal; that the virulence of the poison can be diminished by cultivating the microbes in an appropriate manner; and that when the virulence has been thus diminished their inoculation will afford a protection against the disease.

Meanwhile it had often been observed in hospital practice that a patient with a simple-fractured limb was easily cured, whilst a patient with a compound fracture often died from the wound. Lister was thence led, in 1865, to adopt his antiseptic treatment, by which the wound is protected from hostile microbes.

These investigations, followed by the discovery of the existence of a multitude of micro-organisms and the recognition of some of them—such as the bacillus of tubercle and the comma bacillus of cholera—as essential factors of disease; and by the elaboration by Koch and others of methods by which the several organisms might be isolated, cultivated, and their histories studied, have gradually built up the science of bacteriology. Amongst later developments are the discovery of various so-called antitoxins, such as those of diphtheria and tetanus, and the utilisation of these for the cure of disease. Lister's treatment formed a landmark in the science of surgery, and enabled our surgeons to perform operations never before dreamed of; whilst later discoveries are tending to place the practice of medicine on a firm scientific basis. And the science of bacteriology is leading us to recur to stringent rules for the

[1] In speaking of ferments one must bear in mind that there are two classes of ferments: one, living beings, such as yeast—'organised' ferments, as they are sometimes called—the other the products of living beings themselves, such as pepsin, &c.—'unorganised' ferments. Pasteur worked with the former, very little with the latter

isolation of infectious disease, and to the disinfection (by superheated steam) of materials which have been in contact with the sufferer.

These microbes, whether friendly or hostile, are all capable of multiplying at an enormous rate under favourable conditions. They are found in the air, in water, in the soil; but, fortunately, the presence of one species appears to be detrimental to other species, and sunshine, or even light from the sky, is prejudicial to most of them. Our bodies, when in health, appear to be furnished with special means of resisting attacks, and, so far as regards their influence in causing disease, the success of the attack of a pathogenic organism upon an individual depends, as a rule, in part at least, upon the power of resistance of the individual.

But notwithstanding our knowledge of the danger arising from a state of low health in individuals, and of the universal prevalence of these micro-organisms, how careless we are in guarding the health conditions of everyday life! We have ascertained that pathogenic organisms pervade the air. Why, therefore, do we allow our meat, our fish, our vegetables, our easily contaminated milk, to be exposed to their inroads, often in the foulest localities? We have ascertained that they pervade the water we drink, yet we allow foul water from our dwellings, our pigsties, our farmyards, to pass into ditches without previous clarification, whence it flows into our streams and pollutes our rivers. We know the conditions of occupation which foster ill-health. Why, whilst we remove outside sources of impure air, do we permit the occupation of foul and unhealthy dwellings?

The study of bacteriology has shown us that although some of these organisms may be the accompaniments of disease, yet we owe it to the operation of others that the refuse caused by the cessation of animal and vegetable life is reconverted into food for fresh generations of plants and animals.

These considerations have formed a point of meeting where the biologist, the chemist, the physicist, and the statistician unite with the sanitary engineer in the application of the science of preventive medicine.

Engineering.

Sewage Purification.

The early reports to the Association show that the laws of hydrostatics, hydrodynamics, and hydraulics necessary to the supply and removal of water through pipes and conduits had long been investigated by the mathematician. But the modern sanitary engineer has been driven by the needs of an increasing population to call in the chemist and the biologist to help him to provide pure water and pure air.

The purification and the utilisation of sewage occupied the attention of the British Association as early as 1864, and between 1869 and 1876 a committee of the Association made a series of valuable reports on the subject. The direct application of sewage to land, though effective as a means of purification, entailed difficulties in thickly settled districts, owing to the extent of land required.

The chemical treatment of sewage produced an effluent harmless only after having been passed over land, or if turned into a large and rapid stream, or into a tidal estuary; and it left behind a large amount of sludge to be dealt with.

Hence it was long contended that the simplest plan in favourable localities was to turn the sewage into the sea, and that the consequent loss to the land of the manurial value in the sewage would be recouped by the increase in fish-life.

It was not till the chemist called to his aid the biologist, and came to the help of the engineer, that a scientific system of sewage purification was evolved.

Dr. Frankland many years ago suggested the intermittent filtration of sewage; and Mr. Bailey Denton and Mr. Baldwin Latham were the first engineers to adopt it. But the valuable experiments made in recent years by the State Board of Health in Massachusetts have more clearly explained to us how by this system we may utilise micro-organisms to convert organic impurity in sewage into food fitted for higher forms of life.

To effect this we require, in the first place, a filter about five feet thick of sand and gravel, or, indeed, of any material which affords numerous surfaces or open pores. Secondly, that after a volume of sewage has passed through the filter, an interval of time be allowed, in which the air necessary to support the life of the micro-organisms is enabled to enter the pores of the filter. Thus this system is dependent upon oxygen and time. Under such conditions the organisms necessary for purification are sure to establish themselves in the filter before it has been long in use. Temperature is a secondary consideration.

Imperfect purification can invariably be traced either to a lack of oxygen in the pores of the filter, or to the sewage passing through so quickly that there is not sufficient time for the necessary processes to take place. And the power of any material to purify either sewage or water depends almost entirely upon its ability to hold a sufficient proportion of either sewage or water in contact with a proper amount of air.

Smoke Abatement.

Whilst the sanitary engineer has done much to improve the surface conditions of our towns, to furnish clean water, and to remove our sewage, he has as yet done little to purify town air. Fog is caused by the floating particles of matter in the air becoming weighted with aqueous vapour; some particles, such as salts of ammonia or chloride of sodium, have a greater affinity for moisture than others. You will suffer from fog so long as you keep refuse stored in your towns to furnish ammonia, or so long as you allow your street surfaces to supply dust, of which much consists of powdered horse manure, or so long as you send the products of combustion into the atmosphere. Therefore, when you have adopted mechanical traction for your vehicles in towns you may largely reduce one cause of fog. And if you diminish your black smoke, you will diminish black fogs.

In manufactories you may prevent smoke either by care in firing, by using smokeless coal, or by washing the soot out of the products of consumption in its passage along the flue leading to the main chimney-shaft.

The black smoke from your kitchen may be avoided by the use of coke or of gas. But so long as we retain the hygienic arrangement of the open fire in our living-rooms I despair of finding a fireplace, however well constructed, which will not be used in such a manner as to cause smoke, unless, indeed, the chimneys were reversed and the fumes drawn into some central shaft, where they might be washed before being passed into the atmosphere.

Electricity as a warming and cooking agent would be convenient, cleanly, and economical when generated by water power, or possibly wind power, but it is at present too dear when it has to be generated by means of coal. I can conceive, however, that our descendants may learn so to utilise electricity that they in some future century may be enabled by its means to avoid the smoke in their towns.

Mechanical Engineering.

In other branches of civil and mechanical engineering, the reports in 1831 and 1832 on the state of this science show that the theoretical and practical knowledge of the strength of timber had obtained considerable development. But in 1830, before the introduction of railways, cast iron had been sparingly used in arched bridges for spans of from 160 to 200 feet, and wrought iron had only been applied to large-span iron bridges on the suspension principle, the most notable instance of which was the Menai Suspension Bridge, by Telford. Indeed, whilst the strength of timber had been patiently investigated by engineers, the best form for the use of iron girders and struts was only beginning to attract attention, and the earlier volumes of our Proceedings contained numerous records of the researches of Eaton Hodgkinson, Barlow, Rennie, and others. It was not until twenty years later that Robert Stephenson and William Fairbairn erected the tubular bridge at Menai, followed by the more scientific bridge erected by Brunel at Saltash. These have now been entirely eclipsed by the skill with which the estuary of the Forth has been bridged with a span of 1,700 feet by Sir John Fowler and Sir Benjamin Baker.

The development of the iron industry is due to the association of the chemist with the engineer. The introduction of the hot blast by Neilson, in 1829, in the manufacture of cast iron had effected a large saving of fuel. But the chemical conditions which affect the strength and other qualities of iron, and its combinations with carbon, silicon, phosphorus, and other substances, had at that time scarcely been investigated.

In 1856 Bessemer brought before the British Association at Cheltenham his brilliant discovery for making steel direct from the blast furnace, by which he dispensed with the laborious process of first removing the carbon from pig-iron by puddling, and then adding by cementation the required proportion of carbon to make steel. This discovery, followed by Siemens's regenerative furnace, by Whitworth's compressed steel, and by the use of alloys and by other improvements too numerous to mention here, have revolutionised the conditions under which metals are applied to engineering purposes.

Indeed, few questions are of greater interest, or possess more industrial importance, than those connected with metallic alloys. This is especially true of those alloys which contain the rarer metals; and the extraordinary effects of small quantities of chromium, nickel, tungsten and titanium on certain varieties of steel have exerted profound influence on the manufacture of projectiles and on the construction of our armoured ships.

Of late years, investigations on the properties and structure of alloys have been numerous, and among the more noteworthy researches may be mentioned those of Dewar and Fleming on the distinctive behaviour, as regards the thermo-electric powers and electrical resistance, of metals and alloys at the very low temperatures which may be obtained by the use of liquid air.

Professor Roberts-Austen, on the other hand, has carefully studied the behaviour of alloys at very high temperatures, and by employing his delicate pyrometer has obtained photographic curves which afford additional evidence as to the existence of allotropic modifications of metals, and which have materially strengthened the view that alloys are closely analogous to saline solutions. In this connection it may be stated that the very accurate work of Heycock and Neville on the lowering of the solidifying points of molten metals, which is caused by the presence of other metals, affords a valuable contribution to our knowledge.

Professor Roberts-Austen has, moreover, shown that the effect of any one constituent of an alloy upon the properties of the principal metal has a direct relation to the atomic volumes, and that it is consequently possible to foretell, in a great measure, the effect of any given combination.

A new branch of investigation, which deals with the micro-structure of metals and alloys, is rapidly assuming much importance. It was instituted by Sorby in a communication which he made to the British Association in 1864, and its development is due to many patient workers, among whom M. Osmond occupies a prominent place.

Metallurgical science has brought aluminium into use by cheapening the process of its extraction; and if by means of the wasted forces in our rivers, or possibly of the wind, the extraction be still further cheapened by the aid of electricity, we may not only utilise the metal or its alloys in increasing the spans of our bridges, and in affording strength and lightness in the construction of our ships, but we may hope to obtain a material which may render practicable the dreams of Icarus and of Maxim, and for purposes of rapid transit enable us to navigate the air.

Long before 1831 the steam-engine had been largely used on rivers and lakes, and for short sea passages, although the first Atlantic steam-service was not established till 1838.

As early as 1820 the steam-engine had been applied by Gurney, Hancock, and others to road traction. The absurd impediments placed in their way by road trustees, which, indeed, are still enforced, checked any progress. But the question of mechanical traction on ordinary roads was practically shelved in 1830, at the time of the formation of the British Association, when the locomotive engine was combined with a tubular boiler and an iron road on the Liverpool and Manchester Railway.

Great, however, as was the advance made by the locomotive engine of Robert Stephenson, these earlier engines were only toys compared with the compound engines of to-day which are used for railways, for ships, or for the manufacture of electricity. Indeed, it may be said that the study of the laws of heat, which have led to the introduction of various forms of motive power, are gradually revolutionising all our habits of life.

The improvements in the production of iron, combined with the developed steam-engine, have completely altered the conditions of our commercial intercourse on land; whilst the changes caused by the effects of these improvements in shipbuilding, and on the ocean carrying trade, have been, if anything, still more marked.

At the foundation of the Association all ocean ships were built by hand, of wood, propelled by sails and manœuvred by manual labour; the material limited their length, which did not often exceed 100 feet, and the number of English ships of over 500 tons burden was comparatively small.

In the modern ships steam power takes the place of manual labour. It rolls the plates of which the ship is constructed, bends them to the required shape, cuts, drills and rivets them in their place. It weighs the anchor; it propels the ship in spite of winds or currents; it steers, ventilates, and lights the ship when on the ocean. It takes the cargo on board and discharges it on arrival.

The use of iron favours the construction of ships of a large size, of forms which afford small resistance to the water, and with compartments which make the ships practically unsinkable in heavy seas, or by collision. Their size, the economy with which they are propelled, and the certainty of their arrival, cheapen the cost of transport.

The steam-engine, by compressing air, gives us control over the temperature of cool chambers. In these not only fresh meat, but the delicate produce of the Antipodes, is brought across the ocean to our doors without deterioration.

Whilst railways have done much to alter the social conditions of each individual nation, the application of iron and steam to our ships is revolutionising the international commercial conditions of the world; and it is gradually changing the course of our agriculture, as well as of our domestic life.

But great as have been the developments of science in promoting the commerce of the world, science is asserting its supremacy even to a greater extent in every department of war. And perhaps this application of science affords at a glance, better than almost any other, a convenient illustration of the assistance which the chemical, physical, and electrical sciences are affording to the engineer.

The reception of warlike stores is not now left to the uncertain judgment of 'practical men,' but is confided to officers who have received a special training in chemical analysis, and in the application of physical and electrical science to the tests by which the qualities of explosives, of guns, and of projectiles can be ascertained.

For instance, take explosives. Till quite recently black and brown powders alone were used, the former as old as civilisation, the latter but a small modern improvement adapted to the increased size of guns. But now the whole family of nitro-explosives are rapidly superseding the old powder. These are the direct outcome of chemical knowledge ; they are not mere chance inventions, for every improvement is based on chemical theories, and not on random experiment.

The construction of guns is no longer a haphazard operation. In spite of the enormous forces to be controlled and the sudden violence of their action, the researches of the mathematician have enabled the just proportions to be determined with accuracy ; the labours of the physicist have revealed the internal conditions of the materials employed, and the best means of their favourable employment. Take, for example, Longridge's coiled-wire system, in which each successive layer of which the gun is formed receives the exact proportion of tension which enables all the layers to act in unison. The chemist has rendered it clear that even the smallest quantities of certain ingredients are of supreme importance in affecting the tenacity and trustworthiness of the materials.

The treatment of steel to adapt it to the vast range of duties it has to perform is thus the outcome of patient research. And the use of the metals—manganese, chromium, nickel, molybdenum—as alloys with iron has resulted in the production of steels possessing varied and extraordinary properties. The steel required to resist the conjugate stresses developed, lightning fashion, in a gun necessitates qualities that would not be suitable in the projectile which that gun hurls with a velocity of some 2,500 feet per second against the armoured side of a ship. The armour, again, has to combine extreme superficial hardness with great toughness, and during the last few years these qualities are sought to be attained by the application of the cementation process for adding carbon to one face of the plate, and hardening that face alone by rapid refrigeration.

The introduction of quick-firing guns from ·303 (*i.e.* about one-third) of an inch to 6-inch calibre has rendered necessary the production of metal cartridge-cases of complex forms drawn cold out of solid blocks or plate of the material; this again has taxed the ingenuity of the mechanic in the device of machinery, and of the metallurgist in producing a metal possessed of the necessary ductility and toughness. The cases have to stand a pressure at the moment of firing of as much as twenty-five tons to the square inch—a pressure which exceeds the ordinary elastic limits of the steel of which the gun itself is composed.

There is nothing more wonderful in practical mechanics than the closing of the breech openings of guns, for not only must they be gas-tight at these tremendous pressures, but the mechanism must be such that one man by a single continuous movement shall be able to open or close the breech of the largest gun in some ten or fifteen seconds.

The perfect knowledge of the recoil of guns has enabled the reaction of the discharge to be utilised in compressing air or springs by which guns can be raised from concealed positions in order to deliver their fire, and then made to disappear again for loading ; or the same force has been used to run up the guns automatically immediately after firing, or, as in the case of the Maxim gun, to deliver in the same way a continuous stream of bullets at the rate of ten in one second.

In the manufacture of shot and shell cast iron has been almost superseded by cast and wrought steel, though the hardened Palliser projectiles still hold their place. The forged-steel projectiles are produced by methods very similar to those used in the manufacture of metal cartridge-cases, though the process is carried on at a red heat and by machines much more powerful.

In every department concerned in the production of warlike stores electricity is playing a more and more important part. It has enabled the passage of a shot to be followed from its seat in the gun to its destination.

In the gun, by means of electrical contacts arranged in the bore, a time-curve of the passage of the shot can be determined.

From this the mathematician constructs the velocity-curve, and from this, again, the pressures producing the velocity are estimated, and used to check the same indications obtained by other means. The velocity of the shot after it has left the gun is easily ascertained by the Boulangé apparatus.

Electricity and photography have been laid under contribution for obtaining records of the flight of projectiles and the effects of explosions at the moment of their occurrence. Many of you will recollect Mr. Vernon Boys' marvellous photographs showing the progress of the shot driving before it waves of air in its course.

Electricity and photography also record the properties of metals and their alloys as determined by curves of cooling.

The readiness with which electrical energy can be converted into heat or light has been taken advantage of for the firing of guns, which in their turn can, by the same agency, be laid on the object by means of range-finders placed at a distance and in advantageous and safe positions ; while the electric light is utilised to illumine the sights at night, as well as to search out the objects of attack.

The compact nature of the glow-lamp, the brightness of the light, the circumstance that the light is not due to combustion, and therefore independent of air, facilitates the examination of the bore of guns, the insides of shells, and other similar uses—just as it is used by a doctor to examine the throat of a patient.

Influence of Intercommunication afforded by British Association on Science Progress.

The advances in engineering which have produced the steam-engine, the railway, the telegraph, as well as our engines of war, may be said to be the result of commercial enterprise rendered possible only by the advances which have taken place in the several branches of science since 1831. Having regard to the intimate relations which the several sciences bear to each other, it is abundantly clear that much of this progress could not have taken place in the past, nor could further progress take place in the future, without intercommunication between the students of different branches of science.

The founders of the British Association based its claims to utility upon the power it afforded for this intercommunication. Mr. Vernon Harcourt (the uncle of your present General Secretary), in the address he delivered in 1832, said: 'How feeble is man for any purpose when he stands alone—how strong when united with other men!

'It may be true that the greatest philosophical works have been achieved in privacy, but it is no less true that these works would never have been accomplished had the authors not mingled with men of corresponding pursuits, and from the commerce of ideas often gathered germs of apparently insulated discoveries, and without such material aid would seldom have carried their investigations to a valuable conclusion.'

I claim for the British Association that it has fulfilled the objects of its founders, that it has had a large share in promoting intercommunication and combination.

Our meetings have been successful because they have maintained the true principles of scientific investigation. We have been able to secure the continued presence and concurrence of the master-spirits of science. They have been willing to sacrifice their leisure, and to promote the welfare of the Association, because the meetings have afforded them the means of advancing the sciences to which they are attached.

The Association has, moreover, justified the views of its founders in promoting intercourse between the pursuers of science, both at home and abroad, in a manner which is afforded by no other agency.

The weekly and sessional reunions of the Royal Society, and the annual *soirées* of other scientific societies, promote this intercourse to some extent, but the British Association presents to the young student during its week of meetings easy and continuous social opportunities for making the acquaintance of leaders in science, and thereby obtaining their directing influence.

It thus encourages, in the first place, opportunities of combination, but, what is equally important, it gives at the same time material assistance to the investigators whom it thus brings together.

The reports on the state of science at the present time, as they appear in the last volume of our Proceedings, occupy the same important position, as records of science progress, as that occupied by those Reports in our earlier years. We exhibit no symptom of decay.

Science in Germany fostered by the State and Municipalities.

Our neighbours and rivals rely largely upon the guidance of the State for the promotion of both science teaching and of research. In Germany the foundations of technical and industrial training are laid in the Realschulen, and supplemented by the Higher Technical Schools. In Berlin that splendid institution, the Royal Technical High School, casts into the shade the facilities for education in the various Polytechnics which we are now establishing in London. Moreover, it assists the practical workman by a branch department, which is available to the public for testing building materials, metals, paper, oil, and other matters. The standards of all weights and measures used in trade can be purchased from or tested by the Government Department for Weights and Measures.

For developing pure scientific research and for promoting new applications of science to industrial purposes the German Government, at the instance of von Helmholtz, and aided by the munificence of Werner von Siemens, created the Physikalische Technische Reichsanstalt at Charlottenburg.

This establishment consists of two divisions. The first is charged with pure research, and is at the present time engaged in various thermal, optical, and electrical and other physical investigations. The second branch is employed in operations of delicate standardising to assist the wants of research students—for instance, dilatation, electrical resistances, electric and other forms of light, pressure gauges, recording instruments, thermometers, pyrometers, tuning forks, glass, oil-testing apparatus, viscosity of glycerine, &c.

Dr. Kohlrausch succeeded Helmholtz as president, and takes charge of the first division. Professor Hagen, the director under him, has charge of the second division. A professor is in charge of each of the several sub-departments. Under these are various subordinate posts, held by younger men, selected for previous valuable work, and usually for a limited time.

The general supervision is under a Council consisting of a president, who is a Privy Councillor, and twenty-four members, including the president and director of the Reichsanstalt; of the other members, about ten are professors or heads of physical and astronomical observatories connected with the principal universities in Germany. Three are selected from leading firms in Germany representing mechanical, optical, and electric science, and the remainder are principal scientific officials connected with the Departments of War and Marine, the Royal Observatory at Potsdam, and the Royal Commission for Weights and Measures.

This Council meets in the winter, for such time as may be necessary, for examining the research work done in the first division during the previous year, and for laying down the scheme for research for the ensuing year; as well as for suggesting any requisite improvements in the second division. As a consequence of the position which science occupies in connection with the State in Continental countries, the services of those who have distinguished themselves either in the advancement or in the application of science are recognised by the award of honours; and thus the feeling for science is encouraged throughout the nation.

Assistance to Scientific Research in Great Britain.

Great Britain maintained for a long time a leading position among the nations of the world by virtue of the excellence and accuracy of its workmanship, the result of individual energy; but the progress of mechanical science has made accuracy of workmanship the common property of all nations of the world. Our records show that hitherto, in its efforts to maintain its position by the application of science and the prosecution of research, England has made marvellous advances by means of voluntary effort, illustrated by the splendid munificence of such men as Gassiot, Joseph Whitworth, James Mason, and Ludwig Mond; and, whilst the increasing field of scientific research compels us occasionally to seek for Government assistance, it would be unfortunate if by any change voluntary effort were fettered by State control.

The following are the principal voluntary agencies which help forward scientific research in this country:—The Donation Fund of the Royal Society, derived from its surplus income. The British Association has contributed 60,000*l.* to aid research since its formation. The Royal Institution, founded in the last century, by Count Rumford, for the promotion of research, has assisted the investigations of Davy, of Young, of Faraday, of Frankland, of Tyndall, of Dewar, and of Rayleigh. The City Companies assist scientific research and foster scientific education both by direct contributions and through the City and Guilds Institute. The Commissioners of the Exhibition of 1851 devote 6,000*l.* annually to science research scholarships, to enable students who have passed through a college curriculum and have given evidence of capacity for original research to continue the prosecution of science, with a view to its advance or to its application to the industries of the country. Several scientific societies, as, for instance, the Geographical Society and the Mechanical Engineers, have promoted direct research, each in their own branch of science, out of their surplus income; and every scientific society largely assists research by the publication, not only of its own proceedings, but often of the work going on abroad in the branch of science which it represents.

The growing abundance of matter year by year increases the burden thus thrown on their finances, and the Treasury has recently granted to the Royal Society 1,000*l.* a year, to be spent in aid of the publication of scientific papers not necessarily limited to those of that Society.

The Royal Society has long felt the importance to scientific research of a catalogue of all papers and publications relating to pure and applied science, arranged systematically both as to authors' names and as to subject treated, and the Society has been engaged for some time upon a catalogue of that nature. But the daily increasing magnitude of these publications, coupled with the necessity of issuing the catalogue with adequate promptitude, and at appropriate intervals, renders it a task which could only be performed under International co-operation. The officers of the Royal Society have therefore appealed to the Government to urge Foreign Governments to send delegates to a Conference to be held next July to discuss the desirability and the scope of such a catalogue, and the possibility of preparing it.

The universities and colleges distributed over the country, besides their function of teaching, are large promoters of research, and their voluntary exertions are aided in some cases by contributions from Parliament in alleviation of their expenses.

Certain executive departments of the Government carry on research for their own purposes, which in that respect may be classed as voluntary. The Admiralty maintains the Greenwich Observatory, the Hydrographical Department, and various experimental services; and the War Office maintains its numerous scientific departments. The Treasury maintains a valuable chemical laboratory for Inland Revenue, Customs, and agricultural purposes. The Science and Art Department maintains the Royal College of Science, for the education of teachers and students from elementary schools. It allows the scientific apparatus in the national museum to be used for research purposes by the professors. The Solar Physics Committee, which has carried on numerous researches in solar physics, was appointed by and is responsible to this Department. The Department also administers the Sir Joseph Whitworth engineering research scholarships. Other scientific departments of the Government are aids to research, as, for instance, the Ordnance and the Geological Surveys, the Royal Mint, the Natural History Museum, Kew Gardens, and other lesser establishments in Scotland and Ireland; to which may be added, to some extent, the Standards Department of the Board of Trade, as well as municipal museums, which are gradually spreading over the country.

For direct assistance to voluntary effort the Treasury contributes 4,000*l.* a year to the Royal Society for the promotion of research, which is administered under a board whose members represent all branches of Science. The Treasury, moreover, contributes to marine biological observatories, and in recent years has defrayed the cost of various expeditions for biological and astronomical research, which in the case of the 'Challenger' expedition involved very large sums of money.

In addition to these direct aids to science, Parliament, under the Local Taxation Act, handed over to the County Councils a sum, which amounted in the year 1893 to 615,000*l.*, to be expended on technical education. In many country districts, so far as the advancement of real scientific technical progress in the nation is concerned, much of this money has been wasted for want of knowledge. And whilst it cannot be said that the Government or Parliament have been indifferent to the promotion of scientific education and research, it is a source of regret that the Government did not devote some small portion of this magnificent gift to affording an object-lesson to County Councils in the application of science to technical instruction, which would have suggested the principles which would most usefully guide them in the expenditure of this public money.

Government assistance to science has been based mainly on the principle of helping voluntary effort. The Kew Observatory was initiated as a scientific observatory by the British Association. It is now supported by the Gassiot trust fund, and managed by the Kew Observatory Committee of the Royal Society. Observations on magnetism, on meteorology, and the record of sun-spots, as well as experiments upon new instruments for assisting meteorological, thermometrical, and photographic purposes, are being carried on there. The Committee has also arranged for the verification of scientific measuring instruments, the rating of chronometers, the testing of lenses and of other scientific apparatus. This institution carries on to a limited extent some small portion of the class of work done in Germany by that magnificent institution, the Reichsanstalt at Charlottenburg, but its development is fettered by want of funds. British students of science are compelled to resort to Berlin and Paris when they require to compare their more delicate instruments and apparatus with recognised standards. There could scarcely be a more advantageous addition to the assistance which Government now gives to science than for it to allot a substantial annual sum to the extension of the Kew Observatory, in order to develop it on the model of the Reichsanstalt. It might advantageously retain its connection with the Royal Society, under a Committee of Management representative of the various branches of science concerned, and of all parts of Great Britain.

Conclusion.

The various agencies for scientific education have produced numerous students admirably qualified to pursue research; and at the same time almost every field of industry presents openings for improvement through the development of scientific methods. For instance, agricultural operations alone offer openings for research to the biologist, the chemist, the physicist, the geologist, the engineer, which have hitherto been largely overlooked. If students do not easily find employment, it is chiefly attributable to a want of appreciation for science in the nation at large.

This want of appreciation appears to arise from the fact that those who nearly half a century ago directed the movement of national education were trained in early life in the universities, in which the value of scientific methods was not at that time fully recognised. Hence our elementary, and even our secondary and great public schools, neglected for a long time to encourage the spirit of investigation which develops originality. This defect is diminishing daily.

There is, however, a more intangible cause which may have had influence on the want of appreciation of science by the nation. The Government, which largely profits by science, aids it with money, but it has done very little to develop the national appreciation for science by recognising that its leaders are worthy of honours conferred by the State. Science is not fashionable, and science students—upon whose efforts our progress as a nation so largely depends—have not received the same measure of recognition which the State awards to services rendered by its own officials, by politicians, and by the Army and by the Navy, whose success in future wars will largely depend on the effective applications of science.

The Reports of the British Association afford a complete chronicle of the gradual growth of scientific knowledge since 1831. They show that the Association has fulfilled the objects of its founders in promoting and disseminating a knowledge of science throughout the nation.

The growing connection between the sciences places our annual meeting in the position of an arena where representatives of the different sciences have the opportunity of criticising new discoveries and testing the value of fresh proposals, and the Presidential and Sectional Addresses operate as an annual stock-taking of progress in the several branches of science represented in the Sections. Every year the field of usefulness of the Association is widening. For, whether with the geologist we seek to write the history of the crust of the earth, or with the biologist to trace out the evolution of its inhabitants, or whether with the astronomer, the chemist, and the physicist we endeavour to unravel the constitution of the sun and the planets or the genesis of the nebulæ and stars which make up the universe, on every side we find ourselves surrounded by mysteries which await solution. We are only at the beginning of work.

I have, therefore, full confidence that the future records of the British Association will chronicle a still greater progress than that already achieved, and that the British nation will maintain its leading position amongst the nations of the world, if it will energetically continue its voluntary efforts to promote research, supplemented by that additional help from the Government which ought never to be withheld when a clear case of scientific utility has been established.

REPORTS

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Corresponding Societies.—Report of the Committee, consisting of Professor R. MELDOLA (*Chairman*), Mr. T. V. HOLMES (*Secretary*), Mr. FRANCIS GALTON, Sir DOUGLAS GALTON, Sir RAWSON RAWSON, Mr. G. J. SYMONS, Dr. J. G. GARSON, Sir JOHN EVANS, Mr. J. HOPKINSON, Professor T. G. BONNEY, Mr. W. WHITAKER, Professor E. B. POULTON, Mr. CUTHBERT PEEK, *and* Rev. Canon H. B. TRISTRAM.

THE Corresponding Societies Committee of the British Association beg leave to submit to the General Committee the following Report of the proceedings of the Conference held at Ipswich.

The Council nominated Mr. G. J. Symons, F.R.S., Chairman, Dr. J. G. Garson, Vice-Chairman, and Mr. T. V. Holmes, Secretary to the Ipswich Conference. These nominations were confirmed by the General Committee at the meeting held at Ipswich on Wednesday, September 11. The meetings of the Conference were held at the Co-operative Hall, Ipswich, on Thursday, September 12, and Tuesday, September 17, at 3.30 P.M. The following Corresponding Societies nominated as delegates to represent them at the Ipswich meeting :—

Belfast Natural History and Philosophical Society.	Alexander Tate, M.Inst.C.E.
Berwickshire Naturalists' Club . . .	G. P. Hughes.
Birmingham Natural History and Philosophical Society.	J. Kenward, F.S.A., Assoc.M.Inst.C.E.
Buchan Field Club	John Gray, B.Sc.
Burton-on-Trent Natural History and Archæological Society.	James G. Wells.
Caradoc and Severn Valley Field Club .	W. W. Watts, F.G.S.
Chester Society of Natural Science and Literature.	Osmund W. Jeffs.
Chesterfield and Midland Counties Institution of Engineers.	M. H. Mills, F.G.S., M.Inst.C.E.
Croydon Microscopical and Natural History Club.	W. F. Stanley, F.R.A.S.
Dorset Natural History and Antiquarian Field Club.	Capt. G. R. Elwes.
East Kent Natural History Society .	A. S. Reid, M.A., F.G.S.
East of Scotland Union of Naturalists' Societies.	Prof. D'Arcy W. Thompson, M.A.
Essex Field Club . .	T. V. Holmes, F.G.S.

Federated Institution of Mining Engineers.	M. H. Mills, F.G.S., M.Inst.C.E.
Glasgow Geological Society . . .	J. Barclay Murdoch.
Glasgow Philosophical Society . .	Robert Gow.
Hertfordshire Natural History Society .	John Hopkinson, F.L.S.
Ireland, Statistical and Social Inquiry, Society of.	R. M. Barrington, LL.B.
Isle of Man Natural History and Antiquarian Society.	His Honour Deemster Gill.
Liverpool Geological Society . . .	E. Dickson, F.G.S.
Malton Field Naturalists' and Scientific Society.	Dr. E. Colby.
Manchester Geographical Society . .	Eli Sowerbutts, F.R.G.S.
North Staffordshire Naturalists' Field Club.	C. E. De Rance, F.G.S.
Norfolk and Norwich Naturalists' Society	H. B. Woodward, F.G.S.
North of England Institute of Mining Engineers.	Prof. J. H. Merivale, M.A.
Northamptonshire Natural History Society and Field Club.	C. A. Markham, F.R.Met.Soc.
Perthshire Society of Natural Science .	A. S. Reid, M.A., F.G.S.
Rochdale Literary and Scientific Society	J. Reginald Ashworth, B.Sc.
Royal Cornwall Geological Society . .	T. R. Polwhele.
Somersetshire Archæological and Natural History Society.	F. T. Elworthy.
Warwickshire Naturalists' and Archæologists' Field Club.	W. Andrews, F.G.S.
Woolhope Naturalists' Field Club . .	Rev. J. O. Bevan, M.A.
Yorkshire Naturalists' Union . . .	M. B. Slater, F.L.S.

IPSWICH, FIRST CONFERENCE, SEPTEMBER 12, 1895.

The Corresponding Societies Committee were represented by Professor R. Meldola, Mr. G. J. Symons, Mr. Hopkinson, and Mr. T. V. Holmes (Secretary). The Chairman of the Conference opened the proceedings with the following address:—

Address of the Chairman, G. J. SYMONS, F.R.S.

Just as with the great Association under whose auspices we meet, so with the numerous and intellectual bodies which you represent—each has a double duty. The duty to humanity of doing its best to interpret truthfully the lessons of the world in which we live, so that by increasing knowledge future generations may learn to make better use of its marvellous stores, and perchance repair some of the waste which has gone on in the past, and which is still going on. Our other duty is to advance the cause of the various bodies with which we are connected. Of course you know this as well as I do, but in these days when a universal genius has become an impossibility, and progress can be effected only by limiting one's work to some corner of the field of science, there is great danger of specialisation leading to forgetfulness of generalisation, and of what is the end of all research. You all know the necessity for intercommunication, which in the early years of this century rendered the formation of the British Association imperative, and you know how that need was met. I hold that this Conference and the work which it is doing are an equal necessity of the present time. How could workers in any branch of science know all that was being done by local effort without our index to your proceedings? The world is the better for the knowledge which you gain being rendered generally accessible, and both the British

Association and the local societies gain the strength which arises from federation.

The Council having nominated me to the honourable office of Chairman, my first and most pleasant duty is to offer you a hearty welcome; and my second, which is a somewhat personal one, is to ask you to remember that it is not given to every chairman mentally to photograph every one present, and to remember not merely every face, but the name of its owner; it is one thing to be Chairman whom every one can see and recognise, it is quite another thing for the Chairman to remember all the faces before him. It is therefore from no lack of courtesy, but from the physiological necessity, that I request that each delegate will preface his remarks by mentioning his name, and that of the Society which he represents.

I have already intimated my opinion that if a man wishes to do good work for science he must take some field, or corner of a field, and labour there. I have only a corner—rainfall, but I think that I know enough about some other parts of the field of meteorology to point out spots where good work could be done—and work precisely suitable for the members of your societies. Of course in the few minutes during which I may detain you I cannot enter into details, but there is such an organisation as the Post Office. I do answer as many letters as I can, and an extra twenty or thirty will make no appreciable difference.

Now, to take up the syllabus:—

1. *Meteorological observations in general.*—Do not encourage the keeping of records from any but good instruments, properly placed. A hard frost occurs, and forthwith there is a crop of wonderful records, some from thermometers badly placed, some from thermometers which never were good, some from good thermometers allowed to go wrong. An incorrect statement is much worse than none at all; see to it then that such records as you publish are worthy of your Society. I say no more on this head because the Royal Meteorological Society has published, almost at cost price (1*s.*), an amply illustrated pamphlet, 'Hints to Observers,' which will show any one what, and when, and how, observations ought to be made. It is by no means necessary to start with an elaborate and costly set of instruments; but see to it that the instruments which you do have are good, and that no records except from good and tested instruments, properly placed, ever appear in your volumes.

2. *Sea and river temperature.*—I have interpolated the words 'and river' because I ought to have put them in the syllabus originally, and because my attention has been drawn to the subject by an excellent summary of Dr. Adolf Forster's work upon the temperatures of European rivers, by Mr. H. N. Dickson, given in the September number of 'The Geographical Journal.' You will remember that for a few years there was a Committee of the British Association studying river temperature; and I am sure that if your societies took up the investigation, a fresh committee could be appointed, so that we should not need to go to a German book to learn the details of the temperature of the Thames. The work is easy, healthy, and inexpensive. Easy, because it merely involves a walk to a bridge, a jetty, or a pier-head, the lowering of the thermometer into the water, entering the reading, and carrying it home again; healthy, from the regularity of the walk; and inexpensive, because the verified K. O. thermometer and its copper case, cord, and everything, could be sent to any part of the country complete for a sovereign.

3. *Earth temperature at shallow and at great depths.*—The second half of this subject has often been brought before you, because the Underground Temperature Committee is the oldest one of the British Association. It, as you know, deals chiefly with the temperature in mines and in deep shafts and wells. Any one who can obtain good records at depths of, or exceeding, 1,000 feet can do useful work, but I am doubtful whether much more can be learned in this country by observations at depths between 10 feet and 1,000 feet than we already know. I insert the words, 'in this country,' because I do not think that the law of decrease for tropical and for arctic localities is known. Unfortunately we have no representatives of such localities here, or we might sow a productive seed. Observations at shallow depths—say 3 inches to 10 feet—are becoming less rare than they were, and the time is not distant when the law of temperature variation for shallow depths will be known with sufficient accuracy. That much has yet to be ascertained, many persons learned by burst water-pipes last winter. I mention this as an illustration of the application of scientific records to the welfare of mankind, not as an indication that I consider the mischief to have been wholly produced by soil temperature; but I must not digress.

4. *Phenological work.*—I am afraid that this word 'phenological' has not proved very acceptable. I once heard an inquiry what meteorology had to do with prisons—and it turned out that the querist had overlooked the 'h,' and reading it as 'penological' thought that it must have something to do with punishment. However, I need not tell you that it means the laws of the life history of plants and animals; in fact, an endeavour to record the progress of the seasons not by thermometers or by rain-gauges, but by plants, trees, insects, and birds, and the study of the relations between the indications of the natural history phenomena and those of the instruments and efforts to separate cause and effect. It has always seemed to me a class of work peculiarly adapted for the local scientific societies, for their Botanical and Entomological Sections. The Royal Meteorological Society has spent a considerable sum in promoting this work, and in the hands of Mr. E. Mawley it is progressing. Personally, I am not competent to pronounce any criticism upon the work beyond this, that Mr. Mawley has devoted himself to it, and has produced tables and diagrams of great interest. But I do say this, that I think that the naturalists should either co-operate heartily with the meteorologists, or else should show that the meteorologists are attempting the impossible or the undesirable.

5. *Early meteorological records.*—It is a prevalent idea (especially with executors) that old manuscript books of observations are useless. I have every reason to believe that a long deceased relative of my own assisted in burning part of the oldest record of the rainfall in this country—that begun at Townley in Lancashire in 1677; and what she did at the beginning of this century has been done by scores of others, and will be until mankind are much more thoughtful and much better informed than they yet are. But I am not addressing you in the capacity of executors, but as representatives of large local bodies, many of them with museums and libraries; and I invite you to see to it that any such records that you have are properly cared for.

Another suggestion—the practice is fortunately rapidly spreading of publishing the early parochial registers. If each society represented here would make it a rule to go through all such publications as have been issued within its area, and print in chronological order all the notes on earthquakes, storms, frosts, floods, &c., which can be collected, much good would be done. Of course this can be done for unpublished as well as for published records.

6. *Records of river and well levels.*—The second half of this subject has so often been brought before you by Mr. De Rance, the Secretary of the British Association Committee on Underground Water, that I need merely mention it. The first part refers to a subject involved in my next and last heading, and to which, therefore, I will at once proceed.

7. *Records of floods and the placing of flood-marks.*—It is very strange that Englishmen (Britons I had better say, for our Irish and Scotch friends are equally bad) are so nearly the worst nation in Europe for looking after their rivers. I do not refer to fouling by sewage and by manufacturing refuse, or to defective engineering—I do not know where we stand in those respects—but I refer to records of river levels, to scale marks on the bridges, to automatic recorders of their rise and fall, to arrangements for warning the owners of low-lying property when floods are probable, and to the classification, levelling, and publication in full, of particulars as to old flood-level marks, and the due marking of new ones when floods occur. I do not suggest that your societies should themselves do all this, but that they should bring it before their Parish and County Councils, and couple their request with the offer of any assistance in their power. Of course the suggestion will be received politely, the great cost will be urged, and in many cases nothing will be done. Forgive my detaining you to hear a little true story. Years ago I suggested such arrangements to an influential man in York—nothing was done. In 1892 York had a flood, not so bad as some on record, but one which cost the Corporation a very large sum ; they paid it, and that steed having been stolen they have figuratively locked the stable door by adopting all the arrangements suggested above. If the Councils do not take your advice, they must remember that your attendance will be on their minutes, to be referred to when their town or district suffers as York did.

The Chairman then read a letter which he had received from Mr. R. Ashworth, of the Rochdale Literary and Scientific Society, who regretted his inability to attend and sent some notes showing what meteorological work was being done in his district.

Mr. T. V. Holmes (Secretary) wished to make a few remarks with regard to the list of papers read before the Corresponding Societies and appended to the Report of the Corresponding Societies Committee. He hoped that the secretaries of the various local societies, in sending in their lists, would be very careful where the paper, from its title, might belong to either of two sections, to group it with that section to which it had most affinity. Examination had in some cases caused a paper to be classed with another section than that originally given. It was very necessary also that the names of papers sent in should not be those of mere popular lectures, but of investigations of a more or less original character. It had occasionally happened that when reference had to be made to some paper on the list in order to ascertain its true nature it had been found that the paper in question had not been sent to Burlington House. No paper would in future be placed on the list published by the British Association unless it could be consulted at the Office.

The Chairman then invited discussion on the subjects mentioned in his address.

Captain G. R. Elwes (Dorset) laid upon the table a paper on the rainfall in Dorset, which had been compiled by a member of the Dorset Natural History and Antiquarian Field Club, Mr. Eaton, from records kept in the county of Dorset during the last forty years. It was a most careful and exhaustive piece of work, and was illustrated by maps and diagrams. Mr. Eaton wished to have the paper submitted to that conference of delegates with the view of eliciting remarks upon it.

The Chairman said that Mr. Eaton was an old friend of his, and he had much pleasure in testifying to the excellence of his work. One of the maps of Dorset was shaded so as to show the proportionate amount of the rainfall, the other the varying elevation of the land, and, as might have been expected, there was a fair amount of parallelism between the two. Mr. Eaton's work was an admirable example of the way in which the rainfall of a county should be worked out, a labour especially requiring much patience and perseverance. He wished they could have such memoirs for every county.

Mr. Sowerbutts remarked upon the difficulty of discussing Mr. Eaton's paper in the absence of copies of it, and Professor Meldola said that there was not much to discuss, as the paper had been brought forward simply as an example of the way in which such work should be done. Professor Merivale asked whether it would be possible to obtain copies of Mr. Eaton's paper, and Captain Elwes said that he would do his best to get copies for any gentlemen who would give in their names.

Mr. Hopkinson stated that twenty years ago he began to record the rainfall of Hertfordshire with about twenty observers, and he had since done his best to add to their number, with the result that there were now about forty. The report which he had published last year contained the monthly returns from forty observers in Hertfordshire. He had obtained about thirty daily records, which were worked up and analysed but not published. In the Transactions of the Hertfordshire Natural History Society much space was devoted to meteorological work and to phenology, and he hoped that the Societies in other counties would work similarly at these subjects. He trusted also that delegates would preserve any early meteorological records they might discover.

Mr. De Rance, in illustration of the increasing usefulness of local societies, mentioned the fact that two Committees of the British Association, of which for many years he had been secretary—that on Coast Erosion, and that investigating the Circulation of Underground Waters—had just ceased to exist in consequence of the admirable way in which their work had been taken up by the Corresponding Societies.

His Honour Deemster Gill mentioned that the subject of Coast Erosion had been taken up by a Committee of the Legislature of the Isle of Man, of which he was a member, but their investigations were not yet complete. But they had found that for some twenty miles on the west, the north-west, and the north, erosion had been going on to a very large extent, the evidence showing a destruction of land of about twenty acres to the mile within the last fifty or sixty years. The whole of the information would be sent to the proper Department when the investigation was concluded. Deemster Gill added, in reply to a question, that the portion of the coast mentioned was not rocky but sandy.

The Chairman remarked that the meteorology of the Isle of Man was being looked after by Mr. A. W. Moore, and Deemster Gill added that all that was necessary was being done there in that department.

Mr. Sowerbutts asked whether it was desirable that the Manchester Society should collect the results of observations at the observatories, and forward them to the Meteorological Society, and the Chairman replied that it was just one of the things wanted. Mr. Sowerbutts added that, though there were several observatories whose observations were hardly worth having, there was a thoroughly efficient one in the Park, under the Whitworth Trustees, another at St. Bede's, and a third at the Manchester Waterworks.

Captain Elwes hoped that it might be possible to induce local scientific societies to co-operate for the discovery of flint implements, and the formulation of results. He wished that they would make this branch of investigation a more special feature of their work than it was at present.

Mr. Osmund W. Jeffs, Secretary to the British Association Committee for the Collection and Preservation of Geological Photographs, stated that it had been proposed by the Committee, and adopted by the Council of the British Association, that the photographs collected, should be placed in the Museum of Practical Geology, Jermyn Street. The first part of the collection, consisting of 800 photographs, had already been deposited there, and the rest would be handed over as soon as possible. As, however, a great many parts of the British Isles were still unrepresented, it was proposed that they should go on collecting. From some of the eastern counties no photographs whatever had been sent, and on that very day he had been promised some from that neighbourhood. He hoped, therefore, that the delegates would remember that they were still collecting, and would mention the fact to their respective societies.

Mr. De Rance, after complimenting Mr. Jeffs on the results he had achieved, remarked that it would be a good thing if each society would issue a circular, and send it to other local societies, so that all might know what photographs had been taken in each locality, and were available, and, on the other hand, in what districts photographers were most needed.

Mr. Sowerbutts dwelt on the very valuable results already attained by Mr. Jeffs, and proposed a hearty vote of thanks to him for his exertions. This vote was seconded by His Honour Deemster Gill. After a few words in support of it from the Chairman it was carried unanimously Mr. Jeffs, in acknowledgment of the vote of thanks, said that they were due rather to the Geological Photographs Committee than to himself personally, and that the work could not have been carried out as it had been but for the active co-operation of a great number of the local societies.

Mr. J. B. Murdoch (Glasgow) thought that in too many of their investigations Scotland was excluded. He might mention as an example the British Association Committee for recording the position, &c., of the Erratic Blocks of England, Wales, and Ireland.

Mr. De Rance stated that the Erratic Blocks Committee was formed many years before the meetings of the delegates of the Corresponding Societies began to take place. Any Scottish member of the British Association might have brought the matter before the General Committee and proposed the extension of the work to Scotland.

Some remarks were made by Mr. Sowerbutts and Mr. G. P. Hughes on Scotland as a nursery of boulders, and the Chairman said that his impression was that many years ago some one suggested the inclusion of Scotland in the labours of the Erratic Blocks Committee, and was answered by a speaker who stated that the Royal Society of Edinburgh was already at work on the subject, and that it would be unwise to trespass upon its territory. For his own part he was always pleased to co-operate with his Scottish friends, and had done so on the question of rainfall, and it would appear that in this Erratic Blocks Committee the exclusion of Scotland was the result of deference to her susceptibilities.

Mr. Murdoch replied that it was quite true that for many years a Boulder Committee had existed in Scotland, but the work had been entirely under the control and direction of Mr. Milne Home, who was now dead, and who, for some time before his death, had been unable to get about the country. Mr. Milne Home's Committee had issued eight yearly reports, which were very valuable, as many of the boulders were not only tabulated, but figured. But for some time the work had been practically at a standstill.

The Chairman remarked that in that case it was certainly desirable that steps should be taken to have Scotland included.

Deemster Gill said that the boulders of the Isle of Man were being noted by the Society to which he belonged, but not, he thought, by any extraneous body.

Professor Merivale remarked that for some time they had been discussing matters connected with Section C. He wished, before the meeting ended, to say a few words on Flameless Explosives (Section G). The North of England Institute of Mining Engineers had been continuing their experiments, and had published one report. They were still going on with their labours, and another report would be published shortly. He had nothing to say then as to the results of their experiments.

The Chairman supposed that the Conference was, as usual, in favour of an application to the General Committee for a grant of 30*l.* to enable the Corresponding Societies Committee to carry on its work.

Professor Meldola moved that an application for a grant of 30*l.* should be made, remarking that the amount named was only just sufficient to cover their expenses. The proposition was seconded by Mr. Hopkinson and carried unanimously.

Second Conference, September 17, 1895.

The Corresponding Societies Committee was represented by Dr. Garson (in the chair), Mr. Hopkinson, Mr. Symons, and Mr. T. V. Holmes (Secretary).

Dr. Garson said that Mr. Symons could not take the chair, as he was then at the meeting of the Committee of Recommendations. It was usual at their Second Conference to consider the recommendations from the various Sections respecting work in which it was thought the Corresponding Societies might usefully co-operate. He would therefore, in the first place, call upon the representative of Section A.

Section A.

Mr. White Wallis stated that Mr. Symons, who had been chosen the representative of Section A, had asked him to attend the Conference in his stead. It had been resolved that the Committees for investigating Earth Tremors and Seismological Phenomena in Japan should be merged into one with the title of 'Committee for Seismological Observations.' Its members would be Mr. G. J. Symons, chairman; Mr. C. Davison and Mr. J. Milne, secretaries; Lord Kelvin, Professor W. C. Adams, Mr. C. H. Bottomley, Sir F. J. Bramwell, Professor G. H. Darwin, Mr. Horace Darwin, Mr. G. F. Deacon, Professor J. A. Ewing, Professor A. H. Green, Professor G. C. Knott, Professor G. A. Lebour, Professor R. Meldola, Professor J. Perry, Professor J. H. Poynting, and Dr. I. Roberts. A grant of 80*l.* had been made to this Committee. The Committee for the application of Photography to Meteorology had been re-appointed with a grant of 15*l.*, and the Underground Temperature Committee had been re-appointed without a grant. They were aware that the observatory of Professor Milne in Japan had been destroyed by fire, and that he now had an observatory in the Isle of Wight, hence the merging of the Committee for Seismological Observations with that for the observation of Earth Tremors. It was hoped that Professor Milne, who was particularly clever in designing inexpensive apparatus, might be able to produce suitable apparatus at a small cost for taking seismological observations, which might be widely distributed over the country, and be largely used by members of local scientific societies. With regard to the Meteorological Photographs Committee, no special work for the Corresponding Societies had been suggested by the Committee, who were simply anxious to obtain photographs of lightning, rainbows, halos, &c. The Committee was just then arranging for synchronous photographs of clouds. Near Exeter they had a straight base line about a quarter of a mile long. Photographic observatories had been erected at each end, and there was a signalling apparatus between the two points, so that photographs of passing clouds might be obtained from both observatories simultaneously. Work of this kind, however, would hardly be taken up warmly by those societies which were mainly natural history societies, though he hoped it would commend itself to those more devoted to engineering, geology, and meteorology.

The Chairman hoped that delegates would make special note of the work just described.

The Rev. J. O. Bevan asked if anything was known of the meteorological work formerly done at Stonyhurst by Father Perry. He believed similar work was still being done there, and would like to know if there had been any communication between the authorities at Stonyhurst and the Meteorological Photographs Committee. If meteorological work was still carried on at Stonyhurst, it was important that the Committee should know what was being done there.

Mr. Sowerbutts knew that the work done by Father Perry was still being carried on at Stonyhurst, and that the Father in charge was a highly trained scientific man. He was afraid that town societies could never do anything in noting earth tremors on account of the tremors caused by passing trains, waggons, &c. He did not know any spot within seven miles of Manchester where a recording instrument might safely be placed, unless it were at the bottom of a coal mine.

The Rev. J. O. Bevan believed that these superficial tremors were of short duration and would not affect the observations made with any properly-constructed meteorological instrument. Had they any connection, he asked, with the Observatories at Greenwich and at Kew?

Mr. White Wallis said that the Committee were certainly in communication with both Kew and Greenwich, and he would note the suggestion that they should communicate with Stonyhurst. As regards the supposed difficulty of making observations on earth tremors in towns he might say that modern instruments were practically unaffected by passing vibrations from railway trains, &c. A tremor of such short duration was not represented on these instruments. They had one in a cellar, but though the vibration of a passing train was felt in the house, it was not recorded by the instrument. Darwin's bifilar pendulum was somewhat expensive Professor Milne accomplished the same result in a much simpler way.

The Chairman pointed out that the delegates might understand from what had been said that the whole cost of the needful apparatus would not necessarily exceed from 20*l.* to 25*l.*, including the erection of a suitable column on which to place it.

SECTION C.

Mr. A. S. Reid, representing Section C, remarked that Mr. Osmund Jeffs, Secretary to the Geological Photographs Committee, had wished to resign, but had been persuaded to retain the post for another year, Mr. W. W. Watts having consented to act as co-secretary during that time, and afterwards to become sole secretary. Mr. Jeffs, however, would always be glad to forward any photographs which may reach him. The Committee had at one time thought of bringing their work to a conclusion, but had lately felt that it would not be judicious to do so. The Erratic Blocks Committee had altered their title so as to include Scotland, and had added some Scottish geologists to their list of members. In answer to the Chairman, who asked in what way the Corresponding Societies could assist the Geological Photographs Committee, Mr. Reid replied that the best plan was for persons interested to write to Mr. Jeffs for information. The Committee were sending out a new circular containing instructions as to the best methods of using the camera, and the best kind of camera to use, together with an abstract of the opinions collected on those subjects.

Mr. Sowerbutts wished delegates to remember that platinotype photographs were the best to send, as those printed by the bromide process often faded very rapidly, while platinotype prints would not.

Mr. Murdoch had been glad to learn that Scotland was now included in the sphere of the Erratic Blocks Committee, and hoped that the Earth Tremors Committee, which was still a purely English Committee, would also be modified so as to comprise Scotland.

The Chairman remarked that these and other Committees were composed of members of the British Association who were chosen on account of their special work and quite irrespective of their nationality or place of residence. In some cases there were observers only in England. But, whatever its title, every Committee was anxious to get information from whatever quarter it was obtainable.

Mr. Hopkinson said that as regards the Erratic Blocks Committee, the reason for the exclusion of Scotland was the fact that a similar Committee for Scotland already existed in Edinburgh. In other cases it was simply an oversight. He was glad that the Geological Photographs Committee continued to exist, as there would always be a reason for its existence, one of its chief objects being to obtain photographs of temporary sections.

Mr. Reid remarked that the Committee did not wish to cease to exist, but they hoped the work would be taken up and carried on at the Jermyn Street Museum.

Mr. M. B. Slater thought that an exchange of local geological photographs among the various Corresponding Societies would be a good thing.

Mr. Sowerbutts approved of Mr. Slater's suggestion, and was sure that the Manchester Geographical Society would gladly exchange photographs with any other societies. They were then receiving some very handsome geological photographs from the Carpathian Society.

The Chairman remarked that the Geological and Geographical Societies would be most likely to welcome an exchange of geological photographs.

Mr. Hopkinson thought that most of the Corresponding Societies would wish to exchange geological photographs.

A discussion here took place on some practical difficulties attending the interchange of photographs, such as the burden likely to be laid on the shoulders of the amateur photographer, &c., in which Mr. Gow, Mr. Reid, Mr. Sowerbutts, Mr. Slater, and the Chairman took part. Mr. Hopkinson thought that the work of printing and distributing copies of photographs might easily be done at the Jermyn Street Museum at a small fixed charge, and Mr. Reid inclined towards a plan brought under his notice by Mr. Gray of Belfast. At that town a photographer had been appointed who received the negatives taken by various members of the local society and furnished as many copies as were desired at a small fixed charge. Persecution of the amateur was thus avoided.

Section E.

Mr. Sowerbutts said that the Committee of Section E had passed a resolution referring to the difficulties at present thrown in the way of pupils who wish to become teachers of geography, marks gained in that subject not counting except in certain cases. They had requested the General Committee of the British Association to permit them to have a Committee for the purpose of examining and reporting to the Association on the condition of the teaching of geography in Great Britain. They wished to make a careful examination into the teaching of geography in all schools, especially secondary schools, and to report next year. They had not asked for a grant. It was probable that the Corresponding Societies might be asked to furnish certain information, and he hoped their Secretaries would reply as promptly as possible.

The Rev. J. O. Bevan did not know whether he was in order in referring to the report of the Conference of Delegates at Nottingham. He should have liked to know in what county 'children attending schools were not taught geography in any way.' Having had a large experience of secondary schools, he also considered the statement made at Nottingham that geography is absolutely ignored in secondary schools to be decidedly erroneous, though it was not taught in every primary school except in connection with reading.

Mr. Reid asked if the Committee meant to inquire into the teaching of geography in such schools as Eton and Harrow.

Mr. Sowerbutts replied that they hoped to extend their inquiry from primary schools to the Universities. They wanted the Committee of the Royal Geographical and other societies to see whether some method cannot be devised by which geography may be placed on an equal footing with other subjects, and be made a paying subject to the teacher.

Mr. Hopkinson (Hertfordshire) said that geography was taught in nearly all the schools with which he was acquainted, and was well taught in those of the Church Schools Company.

The Rev. J. O. Bevan remarked that the Geographical Society had instituted examinations in geography in secondary schools, and gave gold medals and other prizes.

Mr. Sowerbutts rejoined that the Royal Geographical Society were so dissatisfied with the results of these examinations—the whole of the medals having been taken by two schools—that they had resolved to discontinue them. The Manchester Geographical Society had had a similar experience in Lancashire, Yorkshire, and Cheshire.

Section H.

Mr. Hartland said that he was there owing to the very sad and sudden bereavement sustained a few weeks ago by Mr. Brabrook, the Chairman of the Ethnographical Survey Committee, who was consequently unable to attend. The Ethnographical Survey was a matter in which the Corresponding Societies were especially capable of rendering assistance. Indeed, without their aid, it was almost impossible that the work could be carried to a successful issue. The Committee drew up in the early part of the year a circular to the local societies offering them copies of the schedule. Hitherto, however, they had met with little response from the local societies. Possibly the schedule was not sufficiently self-explanatory. The work of the Ethnographical Survey had so many branches that one of them could hardly fail to interest the more active members of the local societies. When the Committee had obtained its grant, as it hoped to do, it proposed to begin operations in Galway, having found a thoroughly qualified man to undertake the work, the expense having been estimated at 20*l*. He hoped to be able to report progress at the next meeting, and would be very glad, in the meantime, if the Corresponding Societies would circulate their schedules and bring the Survey under the notice of their members.

Mr. Slater said that he wished to say a few words on behalf of Dr. Colby, who was unavoidably absent. Dr. Colby (Malton) was chairman of a sub-committee which was already going on with the work, though it was not sufficiently advanced to allow of a report this year. However, he hoped to be able to send one next year. The district in which Dr. Colby was working was a very primitive one.

Mr. Hartland remarked that the Malton Naturalists' Society was one of those which had responded to their circular.

The Chairman noted the great variety of the work proposed by the Ethnographical Survey Committee. Besides the physical measurements required, and the colour of the hair, eyes, &c., there was a wide field for the amateur photographer, for those interested in folklore, linguistic differences, place-names, and local variations in tastes and habits. The Ethnographical Committee have a certain number of instruments which they are willing to place in the hands of those who would undertake measurements. The note drawn up by Mr. Hartland would still further exemplify the kind of work required. The Committee had met with great success during the past year, and the work done around Ipswich was very satisfactory. He trusted that the delegates would urge their societies to form local centres everywhere to carry on the work.

Mr. Hartland wished to draw attention to a point which had not been mentioned, the preservation of ancient monuments of all kinds, which should be scheduled, described, and photographed. He had just received a letter from the secretary of a local committee in Pembrokeshire, who stated that some ancient stones and some pit dwellings had already been discovered there.

The Chairman wished to say a word or two about another Committee—that concerned with the measurement of school-children. Many schools had been doing good work in their own way, but, unfortunately, there had been no uniform system, so that the results at one school could not be compared with those at another. The Committee, after inquiring into the various systems practised, had drawn up one which he hoped would prove acceptable to the various schools. It was of the highest importance that some uniform system should be adopted. Professor Windle of Birmingham would be happy to send a schedule of the various measurements required, and of the way in which they should be made.

The Rev. J. O. Bevan spoke of the desirability of expediting the Archæological Survey of the kingdom which had been begun a few years ago. He had been working at the map of Herefordshire for some years, and it was then almost ready for publication. It could not be too widely known that the Society of Antiquaries was willing to bear the expense of printing the maps if the work on them was done in accordance with the conditions laid down. He was surprised that this work had not been taken up more energetically by properly qualified persons in the different districts, so that it might be executed with as little delay as possible. He hoped each delegate would take an early opportunity of reporting the proceedings at these Conferences to the society he represented.

The Chairman believed that it was generally understood that it was the duty of each delegate to report their proceedings to his society.

Mr. Hopkinson stated that he had brought the work of the Ethnographical Survey Committee before the Hertfordshire Natural History Society, but had failed to get the matter taken up. He found that the questions asked were considered too inquisitorial. Possibly a simpler system might be found to answer better in practice, as more persons or societies would then be found willing to undertake the work.

Mr. Hartland replied that, though they hoped in many cases to get the elaborate measurements asked for, they were glad to obtain such measurements and photographs as could be procured. He was afraid that the elaboration of their schedule must have acted to some extent as a deterrent, though it was drawn up as a standard to which they hoped to attain, not as necessarily obligatory in every case. Possibly, if this were understood, societies would respond more warmly to their appeals for help.

Dr. Brett (Hertfordshire) said that since the York meeting of the British Association fifteen years ago it had been his custom as a medical man to record the weight, height, colour of hair and eyes, &c., of children. He had up to that time made about three thousand observations, but had not yet been able to put his records into shape.

Mr. Hopkinson (referring to the Ethnographical Survey) remarked that his experience was that of others as to the difficulty of getting any one to make the very elaborate series of measurements asked for. He would suggest some simpler scheme as an alternative.

Mr. Hartland hoped that members who objected to the elaborate measurements would take up the subjects of dialect, folklore, or historical or prehistoric monuments. They wanted information on all these points.

The Chairman remarked that the work might usefully be divided among various sub-committees. If that were done all societies would do good work in one department or another, if not in all.

The Conference then came to an end.

The Committee recommend the retention of all the societies now on the list except the Cumberland and Westmoreland Association, which has ceased to exist.

The Committee have pleasure in reporting that the Caradoc and Severn Valley Field Club and the Buchan Field Club have been added to the list of Corresponding Societies.

The Corresponding Societies of the British Association for 1895–96.

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Bath Natural History and Antiquarian Field Club, 1855	Bath N. H. A. F. C.	Rev. W. W. Martin, Royal Literary and Scientific Institution, Bath	100	5*s.*	10*s.*	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, B.A.	268	None	1*l.* 1*s.*	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Belfast Nat. F. C.	Museum, College Square. F. J. Bigger, M.R.I.A.	516	5*s.*	5*s.*	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Berwicksh. Nat. Club	Dr. J. Hardy, Oldcambus, Cockburnspath, N.B.	400	10*s.* 6*d.*	7*s.* 6*d.*	History of the Berwickshire Naturalists' Club, annually
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Walter E. Collinge, Mason College, Birmingham	266	None	1*l.* 1*s.*	Journal, monthly; Proceedings, annually.
Bristol Naturalists' Society, 1862	Bristol Nat. Soc.	H. Percy Leonard, Literary and Philosophic Club, 20 Berkeley Square, Bristol.	173	5*s.*	10*s.*	Proceedings, annually.
Buchan Field Club, 1887	Buchan F. C.	J. F. Tocher, 5 Chapel Street, Peterhead	160	5*s.*	5*s.*	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc.	Thomas Gibbs, 30 High Street, Burton-on-Trent	242	None	5*s*	Annual Report. Transactions occasionally.
Caradoc and Severn Valley Field Club, 1893	Car. & Sev. Vall. F. C.	E. S. Cobbold, 37 Castle Street, Shrewsbury.	160	None	5*s.*	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867	Cardiff Nat. Soc.	Walter Cook, 93 St. Mary Street, Cardiff	459	None	10*s.* 6*d.*	Transactions, half-yearly.
Chester Society of Natural Science and Literature, 1871	Chester Soc. Nat. Sci.	Grosvenor Museum, Chester. G. R. Griffith	696	None	5*s.*	Annual Report. Proceedings, occasionally.
Chesterfield and Midland Counties Institution of Engineers, 1871	Chesterf. Mid. Count. Inst.	Stephenson Memorial Hall. W. F. Howard, 15 Cavendish Street, Chesterfield	350	1*l.* 1*s.* None	Members 31*s.* 6*d.*; { Associates and Students 20*s.*	Transactions of Federated Institution of Mining Engineers, about every two months.
Cornwall, Mining Association and Institute of, 1859	Cornw. Min. Assoc. Inst.	William Thomas, C.E., F.G.S., Penelvan, Camborne	341	10*s.* 6*d.*	Minimum, 10*s.* 6*d.*	Transactions, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc.	G. B. Millett, Penzance	92 Membs. 14 Associates	None	1*l.* 1*s.*	Report and Transactions, annually.
Croydon Microscopical and Natural History Club, 1870	Croydon M. N. H. C.	Public Hall, Croydon. R. F. Grundy	242	None	10*s.*	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Dorset N. H. A. F. C.	N. M. Richardson, Montevideo, Chickerel, Weymouth	333	None	10*s.*	Proceedings, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gal. N. H. A. Soc.	Dr. E. J. Chinnock, Grey Friars', Dumfries	174	2*s.* 6*d.*	5*s.*	Transactions and Journal of Proceedings, annually.
East Kent Natural History Society, 1857	E. Kent N. H. Soc.	19 Watling Street, Canterbury. Stephen Horsley	76	None	10*s.* 6*d.*	'South Eastern Naturalist,' occasionally.
East of Scotland Union of Naturalists' Societies, 1884	E. Scot. Union	William D. Sang, 28 Whyte's Causeway, Kirkcaldy, N.B.	10 Societies, 950 Membs.	None	Assessment of 4*d.* per member	Proceedings, occasionally.

Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	H. M. Cadell, B.Sc., 5 St. Andrew Square, Edinburgh	140	10*s.* 6*d.*	12*s.* 6*d.*	Transactions, annually.
Essex Field Club, 1880	Essex F. C.	William Cole, 7 Knighton Villas, Buckhurst Hill, Essex	400	10*s.* 6*d.*	15*s.*	'Essex Naturalist,' monthly.
Federated Institution of Mining Engineers	Fed. Inst. Min. Eng.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	2,300	None	None	Transactions, about every two months.
Glasgow Archæological Society, 1856	Glasgow Arch. Soc.	207 Bath Street, Glasgow. J. Dalrymple Duncan and W. G. Black	343	None	12*s.* 6*d.*	Transactions, annually.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	J. B. Murdoch, Capelrig, Mearns, Glasgow	250	None	10*s.*	Transactions, annually.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	R. S. Wishart, M.A., and John Cairns, jun., 207 Bath Street, Glasgow	320	7*s.* 6*d.*	7*s.* 6*d.*	Proceedings and Transactions, annually.
Glasgow, Philosophical Society of, 1802	Glasgow Phil. Soc.	John Mayer, 207 Bath Street, Glasgow	640	1*l.* 1*s.*	1*l.* 1*s.*	Proceedings, annually; occasional papers.
Hampshire Field Club, 1885	Hants F. C.	Hartley Institution, Southampton. W. Dale, F.G.S.	250	None	7*s.* 6*d.*	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Herts N. H. Soc.	John Hopkinson, F.L.S., The Grange, St. Albans	260	10*s.*	10*s.*	Transactions, quarterly.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	A. J. Crosfield, Carr End, Reigate	88	10*s.*	10*s.*	Proceedings, every two or three years.
Inverness Scientific Society and Field Club, 1875	Inverness Sci. Soc.	J. Moran, Free Library Buildings, Inverness	180	5*s.*	5*s.*	Transactions, occasionally.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland	W. Lawson, 35 Molesworth Street, Dublin	100	None	1*l.*	Journal, annually.
Leeds Geological Association, 1874	Leeds Geol. Assoc	Mechanics' Institution. J. H. Howarth, F.G.S.	129	None	5*s.*, 2*s.* 6*d.*, 1*s.*	Transactions, annually.
Leeds Naturalists' Club and Scientific Association, 1868	Leeds Nat. C. Sci. Assoc.	H. B. Wilson, Westfield, Armley, Leeds	171	None	6*s.*	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	J. M. Gimson, Town Museum, Leicester	313 Membs. & Associates	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Transactions, quarterly.
Liverpool Engineering Society, 1875	Liv'pool E. Soc.	R. C. F. Annett, Royal Institution, Liverpool	274	None	Resident 1*l.* 1*s.* Non-Res. and Students 10*s.* 6*d.*	Transactions, annually.
Liverpool Geological Society, 1858	Liv'pool Geol. Soc.	Royal Institution. H. C. Beasley	50	None	1*l.* 1*s.*	Proceedings, annually.
Liverpool, Literary and Philosophical Society of, 1812	Liv'pool Lit. Phil. Soc.	Royal Institution. J. M. McMaster	284	None	1*l.* 1*s.*; Ladies 10*s.* 6*d.*	Proceedings, annually.
Liverpool Microscopical Society, 1868	Liv'pool Mic. Soc.	Royal Institution. Andrew T. Smith, jun.	91	10*s.* 6*d.*	10*s.* 6*d.*	Report, annually; papers occasionally.
Malton Field Naturalists' and Scientific Society, 1879	Malton F. N. Sci. Soc.	Museum, Yorkersgate, Malton, Yorkshire. Rev. S. Jenkinson	100	None	2*s.* 6*d.*	Naturalists' Notes, monthly.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	P. M. C. Kermode, Hillside, Ramsey, Isle of Man	140	2*s.* 6*d.*	Gentlemen 6*s.*; Ladies 3*s.*	Yn Lioar Manninagh, quarterly
Manchester Geographical Society, 1884	Manch. Geog. Soc.	Eli Sowerbutts, F.R.G.S., 16 St. Mary's Parsonage, Manchester	830	None	Members 1*l.* 1*s.*; Associates 10*s.* 6*d.*	Journal, quarterly.
Manchester Geological Society, 1838	Manch. Geol. Soc.	James Tonge, 36 George Street, Manchester	230	None	1*l.*	Transactions, eight or nine parts per annum.
Manchester Statistical Society, 1833	Manch. Stat. Soc.	63 Brown Street, Manchester. Francis E. M. Beardsall and T. Gregory	220	10*s.* 6*d.*	10*s.* 6*d.*	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick	300	1*s.* 6*d.*	3*s.* and 5*s.*	Report, annually.

CORRESPONDING SOCIETIES, &c. (*continued*).

Full Title and Date of Foundation	Abbreviated Title	Head-quarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Midland Union of Natural History and Scientific Societies, 1877	Mid. Union	T. V. Hodgson, 15 Lordswood Road, Harborne, Birmingham	12 Societies, 1,200 Membs.	—	3*d.* per Member	Report, annually.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat Soc.	W. A. Nicholson, 3 Oxford Street, Norwich	275	None	5*s.*	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	M. Walton Brown, Neville Hall, Newcastle-upon-Tyne	1,000	None	21*s.* and 42*s.*	Transactions of Federated Institution of Mining Engineers, about every two months.
North Staffordshire Naturalists' Field Club and Archæological Society, 1865	N. Staff. N. F. C. A. Soc.	Rev. T. W. Daltry, M.A., Madeley Vicarage, Newcastle, Staffs.	424	5*s.*	5*s.*	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	N'ton. N. H. Soc.	H. N. Dixon, East Park Parade, Northampton	200	None	10*s.*	Journal, quarterly.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Henry Wilkins, 35 Alfreton Road, Nottingham	150	2*s.* 6*d.*	5*s.*	Transactions and Report, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst.	J. Gardner, 3 County Place, Paisley	370	5*s.*	7*s.* 6*d.*	Report, annually; Meteorological Observations, occasionally.
Penzance Natural History and Antiquarian Society, 1839	Penz. N. H. A. Soc.	Museum, Public Buildings, Penzance. Dr. H. Montgomerie	81	None	10*s.* 6*d.*	Report and Transactions, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci.	Tay Street, Perth. S. T. Ellison	280	2*s.* 6*d.*	5*s.* 6*d.*	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, B.Sc., 20 King Street South, Rochdale	254	None	6*s.*	Transactions, biennially.
Rochester Naturalists' Club, 1878	Rochester N. C.	John Hepworth, Union Street, Rochester	150	None	3*s.* 6*d.*, 5*s.*, and 10*s.*	'Rochester Naturalist,' quarterly.
Somersetshire Archæological and Natural History Club, 1848	Som'setsh. A. N. H. Soc.	The Castle, Taunton. F. T. Elworthy	556	10*s.* 6*d.*	10*s.* 6*d.*	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc.	W. H. Finlay, Royal Observatory, Cape Town	68	None	2*l.*	Transactions, annually.
Tyneside Geographical Society, 1887	Tyneside Geog. Soc.	Geographical Institute, Barras Bridge, Newcastle-on-Tyne. G. E. T. Smithson	1,000	None	10*s.*	Journal, half-yearly.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Warw. N. A. F. C.	W. G. Fretton, F.S.A., Hearsall Terrace, Chapel Fields, Coventry	82	2*s.* 6*d.*	5*s.*	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope N. F. C.	Woolhope Club Room, Free Library, Hereford. H. Cecil Moore	227	10*s.*	10*s.*	Transactions, biennially.
Yorkshire Geological and Polytechnic Society, 1837	Yorks. Geol. Poly. Soc.	Wm. Lower Carter, F.G.S., Hopton, Mirfield	180	None	13*s.*	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	Yorks. Nat. Union	W. Denison Roebuck, F.L.S., Sunny Bank, Leeds	444 and 2,283 Associates.	None	Members 10*s.* 6*d.*; Associates 1*d.*	Transactions, annually; 'The Naturalist,' monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc.	Museum, York. T. S. Noble, F.G.S.	450	None	2*l.*	Report, annually.

Index of the more important Papers, and especially those referring to Local Scientific Investigations, published by the above-named Societies during the year ending June 1, 1895.

*** This catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—Mathematical and Physical Science.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Andson, Rev. W.	Meteorology of Dumfries, 1893	Dum. Gal. N. H. A. Soc.	*Trans.*	10	39	1895
Balfour, C. B.	Meteorological Notes from Observations at Newton Don in 1892–93	Berwicksh. Nat. Club	*History*	1892–93	311	1894
Barling, Ivan C.	The Adjustment of Surveying Instruments	Liv'pool E. Soc.	*Trans.*	XV.	35	„
Bartrum, C. O.	An Open-scale Barometer	Fed. Inst. Min. Eng.	„	VII.	553	„
Bayard, F. C.	Report of the Meteorological Sub-Committee for 1893	Croydon M. N. H. C.	„	For 1892-93	90	„
Boys, Rev. H. A.	Meteorological Notes and Observations	N'ton. N. H. Soc.	*Journal*	VIII.	29, 74, 106, 130	„ 1895
„ „	The November Floods	„ „	„	„	125	„
Burrow, J. C.	Photography in Mines	Cornw. R. Geol. Soc.	*Trans.*	XI.	621	„
Clark, J. E.	Fifty Years of Rainfall Records	Yorks. Phil. Soc.	*Report*	For 1894	25	1894
Cleugh, R.	November Gale at Rock Hall Gardens, Northumberland, 1893	Berwicksh. Nat. Club	*History*	1892–93	399	„
Collingwood, F. J. W.	Rainfall at Glanton Pyke, Northumberland, in 1893	„ „	„	„	409	„
Craw, H. Hewat	Note of Rainfall and Temperature at West Foulden during 1893	„ „	„	„	410	„
„ „	Note of Rainfall and Temperature at Rawburn during 1893	„ „	„	„	„	„
Crossman, Sir W.	Meteorological Observations at Cheswick, 1893	„ „	„	„	411	„
Dixon, H. N.	Phenological Observations, 1893	N'ton. N. H. Soc.	*Journal*	VIII.	104	1895
Elliott, O. T.	Photo-Micography	Leicester Lit. Phil. Soc.	*Trans.*	III.	360	1894
Evans, F. G.	The Meteorology and Kindred Phenomena of 1893	Cardiff Nat. Soc.	„	XXVI.	18	„
Henderson, Jas.	Magnetic Declination in Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	273	„

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Hopkinson, John	Report on the Rainfall in Hertfordshire in the year 1893	Herts N. H. Soc.	*Trans.*	VIII.	33	1894
" "	Climatological Observations taken in Hertfordshire in the year 1893	" "	"	"	45	"
" "	Meteorological Observations taken at the Grange, St. Albans, in the year 1893	" "	"	"	57	"
Johnson, R. C.	The New Astronomy: an Account of Astro-Photography	Liv'pool Lit. Phil. Soc.	*Proc.*	XLVIII.	161	"
Law, Wilby	The Thunderstorms of 1893, at Northampton	N'ton. N. H. Soc.	*Journal*	VIII.	18	"
Loney, Peter	Rainfall at Marchmont House, Duns, Berwickshire, in 1893	Berwicksh. Nat. Club	*History*	1892–93	409	"
Parsons, Dr. H. F.	Earth Temperatures	Croydon M. N. H. C.	*Trans.*	For1892-93	61	"
Rhys-Griffiths, P.	Welsh Weather Proverbs	Cardiff Nat. Soc.	"	XXVI.	73	1895
Richardson, N. M.	Report on Rainfall in Dorset in 1893.	Dorset N. H. A. F. C.	*Proc.*	XV.	201	1894
Wells, J. G.	The Weather of 1892.	Burt. N. H. Arch. Soc.	*Report*	III.	13	"
Wells, J. G., and T. Gibbs	The Weather of 1893.	" "	"	"	17	"
Westlake, J.	Mr. W. Hosken Richards's Meteorological Observations at Penzance	Penz. N. H. A. Soc.	*Trans.*	"	101	"
Wright, J. G.	Apochromatic Objectives for the Microscope	Birm. N. H. Phil. Soc.	*Journal*	I.	57	"

Section B.—CHEMISTRY.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Bellamy, C. R.	The Science and Progress of Gas Combustion	Liv'pool E. Soc.	*Trans.*	XV.	146	1894
Clowes, Prof. F.	The Proportion of Carbon Dioxide (Choke-damp) in Air which is Extinctive to Flame	Fed. Inst. Min. Eng.	"	VII.	419	"
Ferguson, Prof. J.	On the First Edition of the Chemical Writings of Democritus and Synesius: Part IV.	Glasgow Phil. Soc.	*Proc.*	XXV.	182	"
" "	Some Early Treatises on Technological Chemistry. Supplement	" "	"	"	224	"
Haldane, J., and W. N. Atkinson	Composition, Occurrence, and Properties of Black-damp	Fed. Inst. Min. Eng.	*Trans.*	VIII.	549	1895
Harvey, S.	Chemistry in Agriculture	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	App.	"

	Explosives Committee: Part I. Air and Combustible Gases					
Keegan, Dr. P. Q.	Notes on the Chemical Analysis of certain Rosaceæ	Yorks. Nat. Union	*The Naturalist*	For 1895	23	"
Kendall, J. D.	Miss-fires	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	605	1894
Morris, G. Harris	The Chemical Action of Light	Burt. N. H. Arch. Soc.	*Trans.*	III.	72	"
Orsman, W. J.	Coal-dust Explosions.	Manch. Geol. Soc.	"	XXIII.	100	1895
Patterson, T. L.	On Sorghum Sugar Experiments in the United States	Glasgow Phil. Soc.	*Proc.*	XXV.	137	1894
Pendlebury, W. H.	Chemistry of Dover Water	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	107	1895
Storrie, John	Roman Iron-making at Ely Racecourse	Cardiff Nat. Soc.	*Trans.*	XXVI.	129	"

Section C.—Geology.

Bedford, J. E.	The Mourne Mountains	Leeds Geol. Assoc.	*Trans.*	IX.	17	1895
Bell, Dugald	The Glaciation of the West of Scotland	Edinb. Geol. Soc.	"	VII.	49	1894
" "	" " "	Glasgow Phil. Soc.	*Proc.*	XXV.	118	"
Bird, Charles	On so-called Changes of Level	Rochester N. C.	*Roch. Naturalist*	II.	257	"
Bolton, Herbert	Note on some Fossil Trees at Doulton's Delf, St. Helen's, Lancashire	Manch. Geol. Soc.	*Trans.*	XXIII.	73	1895
" "	On the Metamorphism of Coal	" "	"	"	122	"
Boulton, W.	The Geology of the Precious Metals	Birm. N. H. Phil. Soc.	*Journal*	I.	79	1894
" "	" " Part II.	" "	"	"	90	1895
Cadell, H. M.	The New Geological Map of the Edinburgh District	Edinb. Geol. Soc.	*Trans.*	VII.	15	1894
" "	Petroleum and Natural Gas	" "	"	"	51	"
Callaway, C.	Fossil Shells from Gloppa	Car. & Sev. Vall. F. C.	"	I. No. 2.	9	1895
Calvert, A. F.	Western Australia and its Goldfields	Edinb. Geol. Soc.	"	VII.	1	1894
Cantrill, T. C.	On some Drift at Bissell Hill, near Kidderminster	Birm. N. H. Phil. Soc.	*Journal*	I.	141	1895
Carter, Rev. W. L.	A Petrological Description of Rock Sections	Leeds Geol. Assoc.	*Trans.*	IX.	11	"
" "	A Peep into Nature's Sculpture Gallery	" "	"	"	12	"
" "	A Walking Tour in Cornwall	" "	"	"	20	"
Cobbold, E. S.	The Surface Appearance of the Dartmoor Granite	Car. & Sev. Vall. F. C.	"	I. No. 2.	3	"
" "	Notes on the Geology of Cornwall	" "	"	"	15	"
Collins, J. H.	Illustrations of Cornish Fossils: Further Notes on *Petralia*	Cornw. R. Geol. Soc.	"	XI.	644	"

Section C.—GEOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Currie, J.	The Copper Mines of Namaqualand	Edinb. Geol. Soc.	*Trans.*	VII.	30	1894
Cuttriss, S. W.	Norway	Leeds Geol. Assoc.	"	IX.	47	1895
Davis, Prof. W. M.	Note on Croll's Glacial Theory	Edinb. Geol. Soc.	"	VII.	77	1894
Dawkins, Prof. W. Boyd	The Probable Range of the Coal-measures in Southern England	Fed. Inst. Min. Eng.	"	"	533	"
" "	The Geology of the Isle of Man	Manch. Geol. Soc.	"	XXIII.	147	1895
Dickson, E.	The Ribble Estuary, with Notes on the Formation of Sand and the Disposal of Dissolved Matter in River Water	Liv'pool Geol. Soc.	*Proc.*	VII.	135	1894
Dickson, E., and P. Holland	Notes on Shell Breccia dredged off the Coast of the Isle of Man; and on the Source of the Carbonate of Lime of the Shells of Marine Organisms	" "	"	"	164	"
Dow, R.	Outcrop of Diabase at Rossie Priory	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	1	1895
Dowker, G.	Report on Lenham Excursion	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	114	"
Dudgeon, P.	Occurrence of Mispickel (Arsenical Pyrites) in the Stewartry of Kirkcudbright	Dum. Gal. N. H. A. Soc.	*Trans.*	10	160	"
Fitzpatrick, J. J.	The Permian Conglomerate of the Vale of Eden	Liv'pool Geol. Soc.	*Proc.*	VII.	212	1894
Foniakoff, A.	The Gold Deposits of Siberia	Fed. Inst. Min. Eng.	*Trans.*	"	445	"
Forsyth, Dr. D.	The Silurian System of Southern Scotland	Leeds Geol. Assoc.	"	IX.	24	1895
" "	Notes on a Trip to Norway	" "	"	"	41	"
Fox, Howard	Presidential Address	Cornw. R. Geol. Soc.	"	XI.	575	"
" "	On some Fossils from the Coast Sections in the Parishes of Padstow and St. Merryn	" "	"	"	634	"
" "	On some Nodular Concretions, resembling Fossil Wood and Fossil Fish, Treworden Wood, Launceston	" "	"	"	684	"
" "	Notes on the Cherts and Associated Rocks of Roundhole Point (Permizen Point), Cataclews Point, and Dinas Head, West of Padstow	" "	"	"	687	"
Garnett-Botfield, W. E.	An Exposure of Stratified Rocks amid the Basalt of the Isle of Mull	Car. & Sev. Vall F. C.	"	I. No. 1	77	1894
Greenly, E.	A Triassic Land Surface	Edinb. Geol. Soc.	"	VII.	45	"
Groom, T. T.	Mountains, Valleys, Lakes, and Fjords	Leeds Geol. Assoc.	"	IX.	34	1895

Gunn, Rev. Geo.	Rocks of Newton Don	Berwicksh. Nat. Club	*History*	1892–93	312	1894
Herdman, Prof. W. A.	Notes on the Submarine Deposits of the Irish Sea	Liv'pool Geol. Soc.	*Proc.*	VII.	171	"
Holmes, T. V., and W. Whitaker	Coal under South-Eastern England	Essex F. C.	*Essex Naturalist*	VIII.	142	"
Horne, John	Two Volcanic Necks in Applecross	Edinb. Geol. Soc.	*Trans.*	VII.	35	"
" "	The Intercrossing of Boulders in the Applecross Mountains	" "	"	"	38	"
Howard, F. T.	The Hæmatite Deposits of South Wales, and the Theories regarding their Formation	Cardiff Nat. Soc.	"	XXVI.	47	"
" "	Underground Water Circulation of Cardiff and its Neighbourhood	" "	"	"	95	1895
Howarth, J. H.	The Permanence of Continents and Oceanic Basins	Leeds Geol. Assoc.	"	IX.	58	"
Hoyle, T. E.	Polarised Light and Mineral Sections	" "	"	"	9	"
Hull, Prof. E.	The Discovery of a concealed Ridge of supposed Cambrian Rocks under the New Red Sandstone of Netherseal, near Ashby-de-la-Zouch, Leicestershire	Fed. Inst. Min. Eng.	"	VIII.	91	1894
Irving, Rev. A.	The Question of Workable Coal-measures beneath Essex	Essex F. C.	*Essex Naturalist*	"	130	"
Jones, D.	Forest of Wyre Coalfield	Car. & Sev. Vall. F. C.	*Trans.*	I, No. 2	72	1895
Kendall, J. D.	A short Description of the Hæmatite Deposit worked by the Salter, Eskett, and Winder Gill Mines, and the Method of working it	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	650	1894
Kendall, Percy F.	The Ancient and Modern Glaciers of North America	Leeds Geol. Assoc.	*Trans.*	IX.	37	1895
" "	The Glacial Geology of the Isle of Man	I. of Man N. H. A. Soc.	*Yn Lioar Manninagh*	I.	397	1894
Kinahan, G. H.	On the Antrim Alumyte	Manch. Geol. Soc.	*Trans.*	XXIII.	165	1895
Landon, Joseph	A Section in Bunter Conglomerate	Birm. N. H. Phil. Soc.	*Journal*	I.	153	"
Lomas, J.	On Artificial Perlitic Structure	Liv'pool Geol. Soc.	*Proc.*	VII.	158	1894
Luff, G.	Shrewsbury Shelly Sand Bed	Car. & Sev. Vall. F. C.	*Trans.*	I. No. 2	21	1895
McDakin, G.	Coast Erosion, and Landslips near Dover	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	132	"
Mansel - Pleydell, J. C.	Kimmeridge Shale	Dorset N. H. A. F. C.	*Proc.*	XV.	172	1894
Martin, J. S.	On the Micaceous Iron Ore near Bovey Tracey	Manch. Geol. Soc.	*Trans.*	XXIII.	162	1895
Mawby, W.	On the Occurrence of Phosphate of Iron coating Sand Grains at Tranmere	Liv'pool Geol. Soc.	*Proc.*	VII.	162	1894
" "	Notes on the Triassic Rocks of New Jersey, U.S.A.	" "	"	"	206	"

Section C.—GEOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Meachem, F. G.	The Search for Coal over the Eastern Boundary Fault of the South Staffordshire Coalfield, with especial reference to the Sinking at Hamstead Colliery and the Working of the Thick Coal Seam	Fed. Inst. Min. Eng.	*Trans.*	VIII.	401	1894
Millett, F. W.	The Foraminifera of the Pliocene Beds of St. Erth	Cornw. R. Geol. Soc.	"	XI.	655	1895
Paul, J. D.	The Leicester Earthquake	Leicester Lit. Phil. Soc.	"	III.	357	1894
Platt, S. S.	Notes on a large Fossil Tree recently found in Shale of the Coal-measures at Sparth Bottoms, Rochdale	Manch. Geol. Soc.	"	XXIII.	65	1895
Randall, J.	Shropshire Coalfields and their Surroundings	Car. & Sev. Vall. F. C.	"	I. No. 2	31	"
Reade, T. M.	The Dublin and Wicklow Shelly-drift	Liv'pool Geol. Soc.	*Proc.*	VII.	183	1894
Reid, James	The Marine Origin of the Old Red Sandstone	Perth Soc. N. Sci.	*Trans. and Proc.*	II.	21	1895
Richardson, Ralph	Kent Cavern and Sir Henry H. Howorth's Flood Theory	Edinb. Geol. Soc.	*Trans.*	VII.	21	1894
" "	Obituary Notice of Mr. Pengelly	" "	"	"	74	"
Russell, R.	The Extension of the West Cumberland Coal-field Southward and Northward under the St. Bees Sandstone	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	276	"
Sanford, W. A.	On the Bones of an Animal resembling the Megalosaur found in the Rhætic Formation at Wedmore	Som'setsh. A. N. H. Soc.	*Proc.*	XL. Pt. II.	227	"
Seward, A. C.	A new British Carboniferous Fossil	Yorks. Nat. Union	*The Naturalist*	For 1894	233	"
Shore, T. W.	Hampshire Valleys and Waterways	Hants F. C.	*Proc.*	III.	29	1895
Somervail, A.	On the probable Age of the Lizard Rocks	Cornw. R. Geol. Soc.	*Trans.*	XI.	662	"
Stephens, H. J.	Some Notes on the Kergilliack Elyan	" "	"	"	674	"
" "	On a supposed Resemblance between the Occurrence of Native Copper in the Lake Superior and Lizard Areas	" "	"	"	680	"
Stevenson, Prof. J. J.	On the New England Coalfields of the United States	Manch. Geol. Soc.	"	XXIII.	117	"
Stirrup, Mark	The True Horizon of the Mammoth	Manch. Geog. Soc.	*Journal*	X.	165	"
" "	On the Fossil Insects of the Primary Periods	Manch. Geol. Soc.	*Trans.*	XXIII.	106	"

	saurus, found with some other bones near Lavernock					
,, ,,	Notes on the Occurrence of Grains of Native Gold in the New Red Marl Strata during the Boring of an Artesian Well at the Phœnix Brewery, Working Street, Cardiff	,, ,,	,,	,,	107	,,
Tate, Thomas	The Yorkshire Boulder Committee and its Eighth Year's Work	Yorks. Nat. Union	*The Naturalist*	For 1894	297	1894
Thompson, Beeby	Geological Notes	N'ton. N. H. Soc.	*Journal*	VIII.	69	,,
Webb, Wilfred M.	Pleistocene Non-Marine Mollusca from Walton-on-the-Naze	Essex F. C.	*Essex Naturalist*	,,	160	,,
Wood, E. P.	British Guiana Goldfields	N. Eng. Inst.	*Trans. Fed. Inst.*	,,	195	,,
Wood, R. H.	The Rio Tinto Copper Mines	Leeds Geol. Assoc.	*Trans.*	IX.	33	1895
Wünsch, E. A.	On Raised Beaches	Cornw. R. Geol. Soc.	,,	XI.	605	,,
,, ,,	On a Logan Stone in the Course of Formation at St. Michael's Mount	,, ,,	,,	,,	669	,,
Young, R. M.	A recent Find of Irish Elk Bones in Belfast	Belfast N. H. Phil. Soc.	*Report & Proc.*	For1893–94	76	,,

Section D.—Zoology.

Adams, Lionel E.	The Mammals of the Ashbourne District of Derbyshire	Yorks. Nat. Union	*The Naturalist*	For 1895	141	1895
Ash, Rev. C. D.	Lepidoptera at Skipworth in 1894	,, ,,	,, ,,	,,	83	,,
Attfield, D. H.	The Lower Micro-organisms and their Relation to Everyday Life	Herts N. H. Soc.	*Trans.*	VIII.	13	1894
Baily, W. E.	The Lepidoptera of Cornwall and the Islands of Scilly	Penz. N. H. A. Soc.	,,	III.	107	,,
Baker, Walter F.	The Yorkshire Naturalists' Union at Sedbergh	Yorks. Nat. Union	*The Naturalist*	For 1894	221	,,
,, ,,	Lincolnshire Naturalists' Union at Lincoln	,, ,,	,, ,,	,,	251	,,
,, ,,	*Hydrobius fuscipes*: Notes on its Life History, Larval Anatomy, &c.	,, ,,	,, ,,	,,	327	,,
,, ,,	Lincolnshire Naturalists at Cleethorpes	,, ,,	,, ,,	,,	349	,,
,, ,,	Yorkshire Naturalists at Knaresborough	,, ,,	,, ,,	For 1895	145	1895
Ball, Thomas	The Pioneer List of Lincolnshire Land and Freshwater Shells	,, ,,	,, ,,	For 1894	287	1894
Bellamy, J. A.	On the Migration of Birds	Mid. Union	*Report*	XVII.	12	,,
Birkenhead, G. A.	Lepidoptera of the Vale of Neath	Cardiff Nat. Soc.	*Trans.*	XXVI.	14	,,

Section D.—ZOOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Bouskell, F.	Urtication in certain Lepidopterous Larvæ: its Causes and Effects	Leicester Lit. Phil. Soc.	*Trans.*	III.	370	1894
Boyd, D. A.	Notes on the Habits of some Common Birds	Glasgow N. H. Soc.	"	IV.	50	"
Bridgman, J. B.	Fauna of Norfolk: Ichneumons	Norf. Norw. Nat. Soc.	"	V.	603	"
Broom, R.	Notes on the Anatomy of a Form of Cyclopean, with Remarks on the Significance of Cyclopeans	Glasgow N. H. Soc.	"	IV.	31	"
Budgen, W., and C. H. Goodman	Notes on the Development of *Gerris najas*	Croydon M. N. H. C.	"	For1892–93	83	"
Buttress, Leonard	Ornithological Notes from North Notts for 1893	Yorks. Nat. Union	*The Naturalist*	For 1894	345	"
Cambridge, Rev. O. P.	Reptiles of Dorset	Dorset N. H. A. F. C.	*Proc.*	XV.	90	"
" "	On New and Rare British Spiders found in 1893, with Rectification of Synonyms	" "	"	"	103	"
Christy, Miller	The Serotine Bat in Essex	Essex F. C.	*Essex Naturalist*	VIII.	162	"
Coates, Henry	Opening Address (on Museums)	Perth Soc. N. Sci.	*Trans. and Proc.*	II.	i	1895
Collinge, W. E.	The Sensory Canal System of Fishes	Car. & Sev. Vall. F. C.	*Trans.*	I. No. 2	71	"
Cordeaux, John	Bird Notes from the Humber District	Yorks. Nat. Union	*The Naturalist*	For 1894	205	1894
" "	Bird Notes from the Humber District in the Autumn of 1894	" "	" "	For 1895	1	1895
" "	Bird Notes from the Humber District in the Winter of 1894–95	" "	" "	"	117	"
" "	Occurrence of the Hump-backed Whale on the Lincolnshire Coast	" "	" "	For 1894	286	1894
Corrie, John	A Note on Birds	Dum. Gal. N. H. A. Soc.	*Trans.*	10	55	1895
Cruttwell, Rev. C. T.	On the British Micro-Lepidoptera	Leicester Lit. Phil. Soc.	"	III.	364	1894
Drane, R.	Natural History Notes from Grassholm	Cardiff Nat. Soc.	"	XXVI.	1	1995
Duthie, Lieut.-Col. W. H. M.	A Mountain Breeding-haunt of the Raven	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	17	1894
Edwards, James	Fauna and Flora of Norfolk: Hemiptera (Third List)	Norf. Norw. Nat. Soc.	*Trans.*	V.	650	1895
Eyre, Rev. W. L. W.	Further Notes on the Mollusca of North Hants	Hants F. C.	*Proc.*	III.	67	1894
Farn, A. B.	The Silkworm Disease: its Cause and Prevention	Croydon M. N. H. C.	*Trans.*	For1892-93	69	"

Forrest, H. E.	The Hydra, Mythical and Real	Car. & Sev. Vall. F. C.	,,	I. No. 1	6	,,
,, ,,	The Function of the Ephippium in the Daphniadæ	,, ,,	,,	,,	64	,,
,, ,,	British Birds' Nests and Eggs	,, ,,	,,	I. No. 2	19, 28	1895
,, ,,	The Marvels of Pond Life	,, ,,	,,	,,	67	,,
Geldart, H. D.	Notes on *Filaria sanguinis hominis* (*nocturna*)	Norf. Norw. Nat. Soc.	,,	V.	547	1894
Gibbs, A. E.	The Wasp Infestation of 1893	Herts N. H. Soc.	,,	VIII.	22	,,
,, ,,	Notes on Lepidoptera observed in Hertfordshire during the year 1893	,, ,,	,,	,,	74	1895
Gibson, Prof. R. J. H.	The Mushroom Beds of the South American Ants	Liv'pool Lit. Phil. Soc.	*Proc.*	XLVIII.	99	1894
Goldsmith, H. St. B.	Addenda to the List of Birds of Somerset	Som'setsh. A. N. H. Soc.	,,	XL. Pt. II.	152	,,
Greene, Richard	Men and Monkeys: their Similarities and their Differences	N'ton. N. H. Soc.	*Journal*	VIII.	6	,,
Gunn, T. E.	Recent Occurrence of the Great Bustard (*Otis tarda*) in Norfolk	Norf. Norw. Nat. Soc.	*Trans.*	V.	656	,,
Gurney, J. H.	Irish Rock Birds	,, ,,	,,	,,	550	,,
,, ,,	Occurrence of the Tropic Bird in England	,, ,,	,,	,,	659	,,
,, ,,	Hybrid Sparrow (*Passer montanus* and *P. domesticus*)	,, ,,	,,	,,	660	,,
Gurney, J. H., and T. Southwell	Fauna and Flora of Norfolk: Birds	,, ,,	,,	,,	642	,,
Harries, F. H.	British Hawks	Car. & Sev. Vall. F. C.	,,	I. No. 2	70	1895
Hewett, William	*Spilosoma lubricipeda* and its Varieties, *radiata eboraci*, *fasciata*, &c., in Yorkshire, Durham, Lincolnshire, &c.	Yorks. Nat. Union	*The Naturalist*	For 1894	353	1894
Hey, Rev. W. C.	Water Beetles taken near Ayton, Scarborough	,, ,,	,, ,,	,,	201	,,
,, ,,	A Woodland Tragedy	,, ,,	,, ,,	,,	208	,,
,, ,,	Additions to the List of Water Beetles taken near Ayton, Scarborough	,, ,,	,, ,,	For 1895	28	1895
Hodgson, T. V.	Synopsis of the British Cladocera	Birm. N. H. Phil. Soc.	*Journal*	I.	101	,,
Hughes, W. H.	The Migration of the Eyes in the Flat Fishes	Rochester N. C.	*Roch. Naturalist*	II.	273	,,
Knight, G. A. F.	Remarks on some of the Land and Fresh-water Mollusca of Palestine	Glasgow N. H. Soc.	*Trans.*	IV.	9	1894
Lewis, Henry	Notes on Birds observed in Hertfordshire during the year 1893	Herts N. H. Soc.	,,	VIII.	49	,,
Lilford, Lord	Notes on the Ornithology of Northamptonshire and Neighbourhood for 1893	N'ton. N. H. Soc.	*Journal*	,,	53	,,
Lowe, Dr. John	Fauna of Norfolk: Fishes	Norf. Norw. Nat Soc.	*Trans.*	V.	634	,,

Section D.—ZOOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
McDakin, G.	Crocodiles	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	130	1895
McGregor, T. M.	The Hemiptera-Heteroptera and Hemiptera-Homoptera, together with a List of Species occurring in Perthshire	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	6	"
" "	Perthshire Entomology	" "	" "	"	29	"
Mackay, Hugh	Ornithological Notes for 1893	Dum. Gal. N. H. A. Soc.	*Trans.*	10	137	"
McKie, John	Recent Zoological Additions to the Kirkcudbright Museum	" " "	"	"	56	"
Mawley, Edward	Report on Phenological Phenomena observed in Hertfordshire during the year 1893	Herts N. H. Soc.	"	VIII.	27	1894
Mayfield, A.	Notes on Norfolk Earthworms	Norf. Norw. Nat. Soc.	"	V.	574	"
Meek, Alex.	Arbuthnot's List of the Fishes of Peterhead Coast, with Notes	Buchan F. C.	"	III.	107	"
Meyrick, E.	Entomological Notes	Marlb. Coll. N. H. Soc.	*Report*	43	108	1895
Newton, Prof. A.	On the Great Flood of 1852–53 in South-Western Norfolk	Norf. Norw. Nat. Soc.	*Trans.*	V.	560	1894
Pickard-Cambridge, Rev. F. O.	A List of the Araneidea of Cumberland and the Lake District	Yorks. Nat. Union	*The Naturalist*	For 1895	29	1895
Richardson, N. M.	Dorset Lepidoptera in 1892–93, with Description of the Larva of *Epischnia Bankesiella*, Richardson	Dorset N. H. A. F. C.	*Proc.*	XV.	59	1894
" "	Report on Observations on the Appearances of Birds, Insects, &c., and the Flowering of Plants, 1893	" "	"	"	195	"
Robertson, D.	*Sacculina carcini*, Thompson	Glasgow N. H. Soc.	*Trans.*	IV.	79	"
" "	*Amphithoe podoceroides*, Rathke, and *Podocerus pulchellus*, Milne Edwards	" "	"	"	80	"
" "	*Buccinum undatum*, Linn.	" "	"	"	81	"
" "	*Anceus maxillaris*, Montagu	" "	"	"	82	"
" "	*Aglaophenia Myriophyllum*, Linn.	" "	"	"	83	"
Roebuck, W. D.	Bibliography: Birds, 1891	Yorks. Nat. Union	*The Naturalist*	For 1894	177	"
" "	" Crustacea, 1884 to 1892	" "	" "	"	271	"
" "	" Lepidoptera, 1891	" "	" "	"	305	"
" "	" Echinodermata, 1884 to 1892	" "	" "	"	363	"
" "	" Protozoa, 1884 to 1892	" "	" "	For 1895	18	1895

„ „	„ Orthoptera, 1884 to 1892	„ „	„ „	„	[illegible]	„
„ „	„ Vermes, 1884 to 1892	„ „	„ „	„	69	„
„ „	Yorkshire Naturalists' Union at Ferrybridge	„ „	„ „	„	107	„
„ „	Bibliography: Cœlenterata, 1884 to 1892	„ „	„ „	„	151	„
Rooper, George	The Natural History of the Salmon	Herts N. H. Soc.	*Trans.*	VIII.	17	1894
Rye, B. G.	Notes on the Varieties of the British Coccinellidæ	Leicester Lit. Phil. Soc.	„	III.	477	1895
Scott, Thomas	On some Entomostraca from Castlemilk, near Rutherglen	Glasgow N. H. Soc.	„	IV.	69	1894
Smith, John	Occurrence of the Clouded-yellow Butterfly (*Colias edusa*, Fab.) in Ayrshire	„ „	„	„	35	„
„ „	*Pholas crispata*, Linn., as a Borer	„ „	„	„	37	„
Southwell, T.	Presidential Address	Norf. Norw. Nat. Soc.	„	V.	509	„
„ „	Address to the Great Yarmouth Section	„ „	„	„	535	„
„ „	On the Occurrence of the Bearded Seal (*Phoca barbata*) on the Norfolk Coast	„ „	„	„	555	„
„ „	Notes on the Herring Fishery of 1893	„ „	„	„	578	„
„ „	Some Additions to the Norfolk and Norwich Museum in the year 1893	„ „	„	„	581	„
„ „	Fauna and Flora of Norfolk: Mammalia (Third List)	„ „	„	„	632	„
Stacy-Watson, C.	Varieties and Distribution of the Herring (*Clupea harengus*, Linn.)	„ „	„	„	584	„
Stephenson, Thos.	Natural History Notes from Whitby, 1892–1894	Yorks. Nat. Union	*The Naturalist*	For 1894	209	„
„ „	Flying Fish off Whitby	„ „	„ „	„	283	„
Thompson, M. L.	Coleoptera in North-East Yorkshire	„ „	„ „	For 1895	103	1895
Whitlock, F. B.	The Migration of the Yellow Wagtail	„ „	„ „	For 1894	175	1894
„ „	Bird Notes from the Mid-Trent Valley for 1894	„ „	„ „	For 1895	63	1895
Winwood, Rev. H. H.	Reminiscences of the Late Rev. L. Blomefield, Founder and President of the Club	Bath N. H. A. F. C.	*Proc.*	VIII.	35	1894
Wood, Rev. F. H.	The Life History of the Emperor Moth (*Saturnia Carpini*)	N'ton. N. H. Soc.	*Journal*	„	113	1895

Section E.—GEOGRAPHY.

Brearley, D. S.	Japan and the Japanese	Tyneside Geog. Soc.	*Journal*	III.	131	1895
Brown, H. T.	A Recent Visit to the Dalmatian Coast	Burt. N. H. Arch. Soc.	*Trans.*	„	43	1894
Cavendish, Capt. A. E. J.	Two Months in Korea	Tyneside Geog. Soc.	*Journal*	„	11	„

Section E.—GEOGRAPHY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Colquhoun, A. R.	The Future of Mashonaland	Manch. Geog. Soc.	*Journal*	X.	150	1895
Crook, H. T.	The Work of the Ordnance Survey in relation to the Report of the Departmental Committee	" "	"	"	138	"
Douglas, Prof. R.K.	China and its People	Tyneside Geog. Soc.	"	III.	5	1894
Dunmore, Earl of	Journeyings in the Pamirs and Central Asia	Manch. Geog. Soc.	"	X.	19	1895
Elliott, J. Steele	St. Kilda and the St. Kildans	Birm. N. H. Phil. Soc.	"	I.	113	"
Gray, John A.	Afghanistan	Manch. Geog. Soc.	"	X.	42	"
Johnston, H. H.	The Commercial Development of Central Africa, and its Beneficent Results on the Slave Traffic	Tyneside Geog. Soc.	"	III.	31	1894
Knowles, T.	Notes on a Sojourn in the Levant	Burt. N. H. Arch. Soc.	*Trans.*	"	32	"
Kropotkin, Prince	The Great Siberian Railway	Tyneside Geog. Soc.	*Journal*	"	116	1895
Lamington, Lord	Siam and Tonquin	Manch. Geog. Soc.	"	X.	66	"
Markham, C. R.	Himalayan Trade Routes	" "	"	"	1	"
Marshall, W. P.	The Grand Cañon of the Colorado River, Arizona	Birm. N. H. Phil. Soc.	"	I.	73	1894
Mellor, E. W.	Notes of a Journey in Portugal in 1893	Manch. Geog. Soc.	"	IX.	227	1895
" "	" " " "	Tyneside Geog. Soc.	"	III.	91	"
Montefiore, A.	The English Polar Expedition	Manch. Geog. Soc.	"	X.	121	"
Oldham, H. Y., and J. D. Wilde	Report on the Examination on the Geography of Yorkshire, 1894	" "	"	"	141	"
Oppenheim, Baron von	Journey through the Syrian Desert to Mosul in 1893	" "	"	"	96	"
Parsons, Dr. H. F.	Notes from the Ardennes	Croydon M. N. H. C.	*Trans.*	For 1892-93	85	1894
Redway, J. W.	Climate and the Gulf Stream	Manch. Geog. Soc.	*Journal*	IX.	258	1895
Reed, J. Howard	Victorian Lecture Society, Work in 1893–94	" "	"	X.	134	"
Sowerbutts, E.	Proposed Railway from Akka (Acre) to Damascus	" "	"	"	148	"
Steinthal, Rev. S. A.	Prince Henry the Navigator	" "	"	"	169	"
Tanner, Col. H. C. B.	The Region of the Himalayas	Tyneside Geog. Soc.	"	III.	133	"
Tcheraz, Prof. Minas	Armenia, the Country and the People	" "	"	"	127	"

Thomson, Gilbert	Above the Snow-line in Scotland	Glasgow Phil. Soc.	*Proc.*	XXV.	98	1894
Wakefield, Rev. T.	East Africa	Manch. Geog. Soc.	*Journal*	X.	172	1895
Watson, Lt.-Col. C. M.	The Suakin-Berber Route to the Sudan	" "	"	"	107	"
Wiggins, Capt. J.	Kara Sea Navigation	Tyneside Geog. Soc.	"	III.	123	"
Younghusband, Capt. F. E.	Chitral, Hunza, and the Hindu Kush	" "	"	"	103	"

Section F.—Economic Science and Statistics.

Bailey, W. F.	The Ulster Tenant-right Custom: its Origin, Characteristics, and Position under the Land Acts	Stat. Soc. Ireland	*Journal*	XI.	12	1894
Barras, George W.	The Glasgow Building Regulations Act, 1892	Glasgow Phil. Soc.	*Proc.*	XXV.	155	"
Battersby, T. S. F.	The Financial Crisis in the United States, 1893–94	Stat. Soc. Ireland	*Journal*	XI.	34	"
Biggs, Col. W. W.	Cotton Corners	Manch. Stat. Soc.	*Trans.*	1894–95	123	1895
Binns, Henry	The Theory of the Yearly Market Movements	" "	"	"	33	"
Bowles, F. J.	Some Recent Developments of Technical Education	Cornw. R. Geol. Soc.	"	XI.	611	"
Castle, E. J.	Rating of Mines	Fed. Inst. Min. Eng.	"	VII.	428	1894
Chalmers, James	Some Important Sanitary Problems	Glasgow Phil. Soc.	*Proc.*	XXV.	208	"
Douglas, Thomas	Presidential Address	N. Eng. Inst.	*Trans. Fed Inst.*	VIII.	238	"
Dyer, Henry	Technical Education in Glasgow and the West of Scotland: a Retrospect and a Prospect	Glasgow Phil. Soc.	*Proc.*	XXV.	23	"
Edge, John H.	Compulsory Purchase as a Substitute for the Revision of Judicial Rents	Stat. Soc. Ireland	*Journal*	XI.	1	"
Ferguson, Prof. J.	On the Work of the Philosophical and other Scientific Societies	Glasgow Phil. Soc.	*Proc.*	XXV.	1	"
Flux, A. W.	Fifty Years' Accounts of the Bank of England.	Manch. Stat. Soc.	*Trans.*	1894–95	65	1895
Gilpin, E., jun.	The Mineral Development of Nova Scotia	Fed. Inst. Min. Eng.	"	VII.	557	1894
Guthrie, Edwin	Local Taxation	Manch. Stat. Soc.	"	1894–95	93	1895
Harty, Spencer	Reply to Mr. Walker's Paper, 'Our Present and Future Water Supply'	Stat. Soc. Ireland	*Journal*	XI.	29	1894
Inglis, John	The Apprentice Question	Glasgow Phil. Soc.	*Proc.*	XXV.	170	"
Kirlew, G. R.	Juvenile Emigration a Social Economy	Manch. Stat. Soc.	*Trans.*	1894–95	135	1895
Knight, Prof. Wm.	The Higher Education of Women	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	88	"

Section F.—Economic Science and Statistics (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Lapage, R. H.	Gold and other Mineral Resources of Western Australia	Fed. Inst. Min. Eng.	*Trans.*	VII.	497	1894
Macindoe, Alex.	On the Report of Lord Herschell's Committee on Indian Currency	Glasgow Phil. Soc.	*Proc.*	XXV.	71	"
Miscampbel, A.	The Salt Industry of Carrickfergus	Fed. Inst. Min. Eng.	*Trans.*	VII.	546	"
Moore, Dr. J. M.	Recent Socialistic and Labour Legislation in New Zealand	Liv'pool Lit. Phil. Soc.	*Proc.*	XLVIII.	107	"
Nevins, Dr. J. B.	Account of the Fazakerley Cottage Homes, near Liverpool	" "	"	"	195	"
Scott, Conway	National Health	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	56	1895
Smart, Dr. Wm.	A Living Wage	Glasgow Phil. Soc.	*Proc.*	XXV.	52	1894
Sopwith, A.	Presidential Address	Fed. Inst. Min. Eng.	*Trans.*	VII.	405	"
Walker, John A.	Our Present and Future Water Supply	Stat. Soc. Ireland	*Journal*	XI.	22	"
Watts, W. H. S.	Betterment, Worsement, and Recoupment	Manch. Stat. Soc.	*Trans.*	1894–95	1	1895

Section G.—Mechanical Science.

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Barbour, James	The Old Water Supply of Dumfries, and the Progress of the Water Supply in the Town	Dum. Gal. N. H. A. Soc.	*Trans.*	10	121	1895
Borlase, W. H.	History and Description of the Greenside Silver-Lead Mine, Patterdale	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	645	1894
Boulnois, H. P.	Inaugural Address: Municipal Engineering	Liv'pool E. Soc.	*Trans.*	XV.	1	"
Boult, W. S.	Some Methods of Regulating Pressure in Electric Light Circuits	" "	"	"	165	"
Brunck, R.	The Brunck Coke Oven and System for the Recovery of Bye-products	N. Eng. Inst.	*Trans. Fed. Inst.*	IX.	47	1895
Burton, G. L.	A Tour in South Africa, with reference to Engineering Work Past and Present	Liv'pool E. Soc.	*Trans.*	XV.	66	1894
Cornish, J. B.	A Chapter in the History of Cornish Mining	Penz. N. H. A. Soc.	"	III.	171	"
Couslon, Frank	Sinking with Rock-drills	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	17	"
Darby, John H.	The Semet-Solvay Coke Oven	" "	" "	IX.	54	1895
Davies, Morgan W.	Timber Bridges and Viaducts	Fed. Inst. Min. Eng.	*Trans.*	VIII.	128	1894

De Grave, L. W.	Continuous Current Dynamos and Motors	Chesterf. Mid. Count. Inst.	*Trans. Fed. Inst.*	IX.	195	1895
Deacon, Maurice	The Use of Expansion Gear as applied to Colliery Engines	" " "	" "	VII.	672	1894
Dougan, John	On the 'Paristagan' System of Building with Concrete	Glasgow Phil. Soc.	*Proc.*	XXV.	90	"
Duncanson, Thos.	Notes on the Distribution of Water Supplies	Liv'pool E. Soc.	*Trans.*	XV.	187	"
Elwen, T. L.	The Effect of an Obstruction in the Airway of a Mine	N. Eng. Inst.	*Trans. Fed. Inst.*	IX.	36	1895
Evanson, F. M.	On Water-saving Machinery	Liv'pool E. Soc.	*Trans.*	XV.	53	1894
Forbes, U. A.	The Relative Progress of Railways and Waterways, and the methods suggested by its consideration for promoting the arrested development of the latter	Fed. Inst. Min. Eng.	"	VIII.	419	1895
Gilpin, E., jun.	Explosions in Nova Scotian Coal Mines	" "	"	"	143	1894
Harcourt, L. F. Vernon	Inland Navigation, with special reference to the Birmingham District	" "	"	"	511	1895
Hay, William	Banking-out, Screening, and Mechanical Arrangements for Direct Sorting and Packing of Coal	Chesterf. Mid. Count. Inst.	*Trans. Fed. Inst.*	IX.	184	"
Hewitt, H. R.	An Underground Endless Rope at the Moston Colliery, Manchester	" " "	" "	VIII.	377	1894
Holmes, A. B.	The Public Supply of Electrical Energy: its Cost and Price	Liv'pool E. Soc.	*Trans.*	XV.	86	"
James, H. M.	Description of the Whitehaven Collieries	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	641	"
Jeans, J. S.	The Comparative Conditions and Costs of Transport by Railway and Canal	Fed. Inst. Min. Eng.	*Trans.*	VIII.	432	1895
Macassey, L. L.	The Mourne Water Scheme	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	23	"
MacWhirter, Wm.	Modern Electrical Inventions	" "	" "	"	52	"
Main, J. M.	The Working of Hæmatite in the Whitehaven District	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	31	1894
Martin, E. D.	The Severn Navigation, with particular reference to Recent Improvements	Fed. Inst. Min. Eng.	*Trans.*	"	499	1895
Mathews, D. H. F.	On Damping Dust in Mines	Manch. Geol. Soc.	"	XXIII.	90	"
Mellon, H.	The Mining of the Softer Ores of Furness	N. Eng. Inst.	*Trans. Fed. Inst.*	VIII.	44	1894
Moore, R. W.	Historical Sketch of the Whitehaven Collieries	" "	" "	VII.	613	"
" "	Improvement in Brick-kilns	" "	" "	VIII.	26	"
Morgan, James	Street Pavements	Liv'pool E. Soc.	*Trans.*	XV.	104	"
Morison, John	Walling and Sinking Simultaneously with the Galloway Scaffold	Fed. Inst. Min. Eng.	"	VIII.	118	"

Section G.—MECHANICAL SCIENCE (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Roche, George	The American Mail Service	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	67	1895
Saint, William	Improvements in Water-spraying Apparatus for Damping Dust in Mines	Manch. Geol. Soc.	*Trans.*	XXIII.	225	"
Salt, W.	Canals and their Improvements, more particularly applying to the London and Birmingham Trade	Fed. Inst. Min. Eng.	"	VIII.	526	"
Saner, J. A.	Canals	" "	"	"	467	"
" "	Some English Waterways	Liv'pool E. Soc.	"	XV.	14	1894
Sayers, W. B.	On Dynamo-Electric Machinery	Glasgow Phil. Soc.	*Proc.*	XXV.	196	"
Scoular, George	Description of the St. Helen's Colliery, Workington	N. Eng. Inst.	*Trans. Fed. Inst.*	VII.	643	"
Siemens, Alex.	Electric Transmission of Power	" "	" "	VIII.	247	"
Spargo, Edmund	Lithographic Stone and its Uses	Fed. Inst. Min. Eng.	*Trans.*	"	568	1895
Spencer, Wm.	Presidential Address	Chesterf. Mid. Count. Inst.	*Trans. Fed. Inst.*	VII.	661	1894
Statefeldt, C. A.	The Statefeldt Furnace	Fed. Inst. Min. Eng.	*Trans.*	VIII.	93	"
Tate, Simon	Saving of Life from After-damp, Smoke, or Fumes in Mines	N. Eng. Inst.	*Trans. Fed. Inst.*	"	189	"
Thwaite, B. H.	Engineering Heliography, or the Sun-print Copying of Engineering Drawings	" "	" "	IX.	69	1895
Watts, William	On Waterworks Construction and the Use of Concrete and Earthwork in forming Embankments	Manch. Geol. Soc.	*Trans.*	XXIII.	42	1894
" "	Notes on the Use of Mortar and Grout in Masonry and Brickwork	" "	"	"	190	1895
" "	Notes on Concrete	" "	"	"	201	"
Webb, A.	The Patent Light Safety Lamp	" "	"	"	218	"
Wells, Lionel B.	Canals	Fed. Inst. Min. Eng.	"	VIII.	443	"
Wheeler, W. H.	Birmingham and its Canal Connections with the Seaports	" "	"	"	532	"
Wilson, Joseph R.	The Shaw Gas-tester for detecting the Presence and Percentage of Fire-damp and Choke-damp in Coal Mines	" "	"	"	161	1894
Wood, W. O.	The Murton Coal-washer	N. Eng. Inst.	*Trans. Fed. Inst.*	IX.	42	1895

Section H.—ANTHROPOLOGY.

Auden, Rev. T.	The Saxon Settlement of Shropshire	Car. & Sev. Vall. F. C.	*Trans.*	I. No. 1	59	1894
Bulleid, A.	The Lake Village near Glastonbury	Som'setsh. A. N. H. Soc.	*Proc.*	XL. Pt. II.	141	„
Coles, F. R.	The Cairns of Kirkcudbrightshire	Dum. Gal. N. H. A. Soc.	*Trans.*	10	59	1895
Cunnington, E.	The Helstone on Ridge Hill, Portesham	Dorset N. H. A. F. C.	*Proc.*	XV.	52	1894
Darwin, W. E.	Bronze Implements found at Bitterne	Hants F. C.	„	III.	53	1895
Evans, Sir John	The Bronze Age	Herts N. H. Soc.	*Trans.*	VIII.	1	1894
Forrest, Rev. Jas.	Note on a supposed Ancient Grave at Crimonmogate	Buchan F. C.	„	III.	119	„
Gregor, Rev. W.	Kilns, Mills, Millers, Meal, and Bread	„ „	„	„	125	„
Groves, T. B.	Some Local Stone Marks	Dorset N. H. A. F. C.	*Proc.*	XV.	167	„
Hardy, Dr.	On Three British Cists, one of them containing an Urn, found near Callaly Castle, Northumberland, in 1891	Berwicks. Nat. Club	*History*	1892–93	390	„
„ „	On some Prehistoric Antiquities from the Eastern Borders	„ „	„	„	391	„
Huggup, R. G.	On a Dagger and Buckle found with a Skeleton on the Inner Farne Island	„ „	„	„	398	„
James, Ivor	An Account of a Visit to examine certain Groups of Ancient Circular Shallow Excavations on the Mountains of Monmouth and Brecon	Cardiff Nat. Soc.	*Trans.*	XXVI.	55	„
Lach-Szyrma, Rev. W. S.	The Pre-Aryan People of Ancient Cornwall	Penz. N. H. A. Soc.	„	III.	177	„
Laidlaw, W.	On the Remains of the Roman Station at Cappuck, Roxburgh	Berwicksh. Nat. Club	*History*	1892–93	382	„
Lithgow, Douglas	Gossipings about the Parish of Saul	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	41	1895
Lovett, Edward	Report on the Opening of a Round Barrow, and a supposed Saxon Burial, on the South Downs near Arundel, April 15, 1893	Croydon M. N. H. C.	*Trans.*	For 1892-93	77	1894
Macpherson, Capt. J. F.	On the Stature of the Men of Roxburgh and Selkirk Shires	Berwicksh. Nat. Club	*History*	1892–93	314	„
Meyrick, E.	Anthropometrical Statistics	Marlb. Coll. N. H. Soc.	*Report*	43	152	1895
Milligan, S. F.	Irish Archæology	Belfast N. H. Phil. Soc.	*Report and Proc.*	For 1893-94	78	„
Morland, J.	On some Roman Remains at Long Sutton, Somerset	Som'setsh. A. N. H. Soc.	*Proc.*	XL. Pt. II.	272	1894
Moxon, R.	Westminster Abbey and its Monuments	Burt. N. H. Arch. Soc.	*Trans.*	III.	19	„
Murray, A. D.	Recent Investigations of the Roman Wall between the Tyne and Solway	Dum. Gal. N. H. A. Soc.	„	10	45	1895

Section H.—ANTHROPOLOGY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Pub-lished
Newton, John	Recent Discoveries as to the Origin and Early History of the Human Race, contrasted with the Old Ideas	Liv'pool. Lit Phil. Soc.	*Proc.*	XLVIII.	135	1894
Rogers, Robert	Snails (Notes on Folk-lore, Local Traditions)	N'ton. N. H. Soc.	*Journal*	VIII.	97	"
Ross, Dr. David	Some Notes on the Place-names and Dialect of Shetland	Glasgow Phil. Soc.	*Proc.*	XXV.	108	"
Shaw, James	Words collected from the Dumfriesshire Dialect during the last Thirty Years	Dum. Gal. N. H. A. Soc.	*Trans.*	10	139	1895
Stokes, Rev. Dr. G.	St. Patrick and the Valley of the Boyne	Belfast N. H. Phil. Soc.	*Report and Proc.*	For1893-94	19	"
Storrie, John	Ancient Remains on Ely Racecourse	Cardiff Nat. Soc.	*Trans.*	XXVI.	125	"
Stradling, Arthur	A Wonderful Animal [Man]	Herts N. H. Soc.	"	VIII.	85	"
Tannahill, T. F.	Remarks on [Human] Bones found in the District	Rochester N. C.	*Roch. Naturalist*	II.	247	1894
Tregelles, G. F.	The Stone Circles of Cornwall	Penz. N. H. A. Soc.	*Trans.*	III.	147	"
Winstone, Dr. B.	Two Prehistoric Weapons recently found near Epping	Essex F. C.	*Essex Naturalist*	VIII.	163	"

Section I.—PHYSIOLOGY.

Allen, Prof. F. J.	The Modus Operandi of the Nervous System	Birm. N. H. Phil. Soc.	*Journal*	I.	37	1894
Mott, F. T	Stimulation	Leicester Lit. Phil. Soc.	*Trans.*	III.	387	1894

Section K.—BOTANY.

Anderson, Adam	List of some of the Rarer Plants found chiefly in Berwickshire	Berwicksh. Nat. Club	*History*	1892–93	405	1894
Barclay, William	The Summer Excursions of 1894	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	xxx	1895
Bell, George	Early Flowers in 1893	Dum. Gal. N. H. A. Soc.	*Trans.*	10	28	"
Bennett, A.	Notes on the Plants of Northumberland and Durham, in relation to their Extension Northwards to Dumfries, Kirkcudbright, and Wigtown	" "	"	"	132	"

Boyd, D. A.	The Ustilagineæ of North Ayrshire	Glasgow N. H. Soc.	„	IV.	24	1894
„ „	The Peronosporeæ of North Ayrshire	„ „	„	„	28	„
Cooper, E. F.	Notes on the Leicestershire Potamogetons	Leicester Lit. Phil. Soc.	„	III.	430	1895
Crossland, Charles	Additions to the West Riding Fungus Flora	Yorks. Nat. Union	*The Naturalist*	For 1894	165	1894
Dixon, H. N.	A Botanical Trip to Scotland	N'ton. N. H. Soc.	*Journal*	VIII.	1	„
„ „	Notes on Rare Plants [of Northamptonshire]	„ „	„	„	64	1895
Dowker, G.	Plant Movements	E. Kent N. H. Soc.	*S. E. Naturalist*	IV.	116	„
Ellacombe, Rev. Canon	The Weather of the past Season and its Effects on the Garden	Bath N. H. A. F. C.	*Proc.*	VIII.	11	1894
Ewing, P.	*Alchemilla vulgaris*, Linn., and Allied Forms	Glasgow N. H. Soc.	*Trans.*	IV.	40	„
Fielding, Rev. C.H.	General Wild Flowers	Rochester N. C.	*Roch. Naturalist*	II.	264, 282	„
Fingland, James	Notes on the *Rubi* and *Salices* of Upper Nithsdale	Dum. Gal. N. H. A. Soc.	*Trans.*	10	160	1895
Gibbs, T., and E. Snelgrove	Botanical Notes from the Sheffield District	Yorks. Nat. Union	*The Naturalist*	For 1895	7	„
Hamilton, W. P.	Reproduction of Mosses	Car. & Sev. Vall. F. C.	*Trans.*	I. No. 1	21	1894
Johnstone, J. T.	Botanical Notes for the Moffat District for 1892–93	Dum. Gal. N. H. A. Soc.	„	10	36	1895
King, Prof. T., and D. A. Boyd	Report on the Disappearance of Native Plants	Glasgow N. H. Soc.	„	IV.	44	1894
„ „	List of Fungi, &c., observed at Kilmahew, Finlaystone, and West Kilbride	„ „	„	„	61	„
Linton, Rev. E. F.	Some Additions to the Dorset Flora	Dorset N. H. A. F. C.	*Proc.*	XV.	74	„
„	British Species of *Utricularia* (illustrated by Dorset Specimens)	„ „	„	„	81	„
McAndrew, James	Botanical Notes for 1893	Dum. Gal. N. H. A. Soc.	*Trans.*	10	10	1895
„ „	A List of Wigtownshire Plants	„ „	„	„	72	„
Mansell - Pleydell, J. C.	On some of the Rarer Trees in the Gardens of Abbotsbury Castle	Dorset N. H. A. F. C.	*Proc.*	XV.	184	1894
Meyrick, E.	Botanical Notes	Marlb. Coll. N. H Soc.	*Report*	43	98	1895
Miller, Rev. J. K., and Rev. E. A. Woodruffe-Peacock	The Rarer Plants of the Walkeringham Neighbourhood in Nottinghamshire, Lincolnshire, and Yorkshire	Yorks. Nat. Union	*The Naturalist*	For 1895	159	„
Mott, F. T.	The Leicestershire Hepaticæ	Leicester Lit. Phil. Soc.	*Trans.*	III.	472	„
Murray, Rev. R. P.	The Flora of Somerset: Second Instalment	Som'setsh. A. N. H. Soc.	*Proc.*	XL. Pt. III.	97	1894
O'Gorman, D. A.	Ginseng and its Cultivation in Corea	Manch. Geog. Soc.	*Journal*	IX.	262	1895
Petty, Lister	The Constituents of the North Lancashire Flora	Yorks. Nat. Union	*The Naturalist*	For 1894	243	1894
				For 1895	53	1895

Section K.—BOTANY (*continued*).

Name of Author	Title of Paper	Abbreviated Title of Society	Title of Publication	Volume or Part	Page	Published
Petty, Lister	The Constituents of the North Lancashire Flora, 1597 (?)–1893	Yorks. Nat. Union	*The Naturalist*	For 1894 For 1895	289 133	1894 1895
Phillips, W.	A Word on Bladderworts	Car. & Sev. Vall. F. C.	*Trans.*	I. No. 1	1	1894
" "	*Puccinia*	" "	"	I. No. 2	6	1895
Preston, Rev. T. A.	The Flora of the Cropstone Reservoir	Leicester Lit. Phil. Soc.	"	III.	430	"
Roebuck, W. D.	Bibliography: Freshwater Algæ, 1888 to 1892	Yorks. Nat. Union	*The Naturalist*	For 1895	129	"
Russell, Miss	The Oak beside the River at Ashiesteel	Berwicksh. Nat. Club	*History*	1892–93	335	1894
" "	Roses in Selkirkshire, &c.	" "	"	"	336	"
Saunders, James	Further Notes on the Mycetozoa, with a List of Species from Herts, Beds, and Bucks	Herts N. H. Soc.	*Trans.*	VIII.	65	"
Shaw, William	List of some Rarer Berwickshire Plants	Berwicksh. Nat. Club	*History*	1892–93	401	"
Shenstone, J. C.	The Oak Tree in Essex	Essex F. C.	*Essex Naturalist*	VIII.	89	"
Soppitt, H. T.	Botanical Rambles about Arnside	Yorks. Nat. Union	*The Naturalist*	For 1894	265	"
Teague, A. H.	Some Curious Fungi	Penz. N. H. A. Soc.	*Trans.*	III.	175	"
Vachell, Dr. C. T.	Contribution towards an Account of the *Narcissi* of South Wales	Cardiff Nat. Soc.	"	XXVI.	81	1895
" "	Note on a Doubtful Species of *Senecio*	" "	"	"	110	"
Wells, J. G.	Report of the Botanical and Microscopical Section, 1892–93	Burt. N. H. Arch. Soc.	*Report*	III.	11	1894
White, Dr. F. B.	Notes on Summer Excursions of 1893	Perths. Soc. N. Sci.	*Trans. and Proc.*	II.	v	1895
Whitton, James	Meteorological Notes and Remarks upon the Weather during the Year 1893, with its General Effects upon Vegetation	Glasgow N. H. Soc.	*Trans.*	IV.	16	1894
Wilkinson, H. J.	Catalogue of the British Plants in the Herbarium of the Yorkshire Philosophical Society: Part I. Ranunculaceæ to Fumariaceæ	Yorks. Phil. Soc.	*Report*	For 1894	1	"
Wood, William	Plants of Newton Don	Berwicksh. Nat. Club	*History*	1892–93	403	"
Woodd, C. H. B.	The Flora of a Pothole	Yorks. Nat. Union	*The Naturalist*	For 1894	268	"
" "	Botanical Notes from Langstrothdale	" "	" "	"	285	"
Woodruffe - Peacock, Rev. E. A.	A Critical Catalogue of Lincolnshire Plants	" "	" "	For 1894 For 1895	213, 257, 337 95	" 1895

Underground Temperature.—Twenty-first Report of the Committee, consisting of Professor J. D. EVERETT (*Chairman and Secretary*), LORD KELVIN, Mr. G. J. SYMONS, Sir A. GEIKIE, Mr. J. GLAISHER, Professor E. HULL, Professor J. PRESTWICH, Dr. C. LE NEVE-FOSTER, Professor A. S. HERSCHEL, Professor G. A. LEBOUR, Mr. A. B. WYNNE, Mr. W. GALLOWAY, Mr. JOSEPH DICKINSON, Mr. G. F. DEACON, Mr. E. WETHERED, Mr. A. STRAHAN, *and* Professor MICHIE SMITH. (*Drawn up by* Professor EVERETT.)

INFORMATION as to underground temperature in the southern hemisphere has hitherto been very scanty. Importance therefore attaches to observations which have recently been taken in a deep bore in New South Wales by T. W. Edgeworth David, Professor of Geology in Sydney University, and E. F. Pittman, Government Geologist. The following account is derived from a paper by these gentlemen to the Royal Society of N.S.W., read December 6, 1893, supplemented by letters from Professor David to the Secretary of the Committee.

The bore is 2,929 ft. deep, and is the second of two which have been sunk at Cremorne on the shores of Port Jackson.

A protected maximum thermometer had been furnished by the secretary to Professor David when he went out to Sydney in 1882; but it had passed through several hands, and was not forthcoming when the opportunity for observation occurred. Professor David had accordingly to avail himself of such instruments as were accessible, and he borrowed four maximum thermometers, including two inverted Negretti's belonging to Mr. H. C. Russell, the Government Astronomer, which had Kew certificates. They were similar in pattern to those adopted by the Committee, except that there was no outer glass-case. In place of this, 'a strong piece of wrought iron water-pipe, about two feet three inches in length,' was employed. 'A cap-piece was sweated on to the lower end of this tube, the threads of the screw in the cap-piece and pipe being filled with molten solder, and the cap-piece being screwed on while the solder was still molten.' 'The lower end of the pipe was then filled to a depth of about two inches with brass turnings. The thermometers were next carefully lowered into the tube.' They had their bulbs uppermost, as usual. 'Brass turnings were then packed around them in order that the heat might be conducted rapidly to their bulbs from the water in the bore. Strings were fastened to the bulbs to facilitate the withdrawal of the thermometers from the tube after the experiment of taking the temperature had been completed. The ends of these strings were carried close up to the top of the pipe, the brass turnings being packed around them like tamping around a fuse in a shot-hole. A few cardboard wads and a layer of loose paper two inches in thickness were inserted in the upper portion of the tube, to prevent the conduction downwards of the artificial heat, which would otherwise travel down to the thermometers from the upper end of the tube when it was dipped in the molten solder, previous to the upper cap-piece being sweated on. A ring-bolt for attaching the lowering cord was screwed into the upper cap-piece, with molten solder sweated into it; and the whole cap-piece was then screwed and sweated on to the upper end of the tube in the same manner as the lower cap-piece.'

The first experiment was a failure, the thermometers, though left for about an hour near the bottom of the bore, indicating about the same temperature that they had before lowering. This failure is attributed either to the non-conducting action of a few thicknesses of soft paper in which the bulbs were wrapped, or to the mercury which had left the bulbs having returned to them again while the tube was being conveyed from the bore to the plumber's shop, where the cap-piece was removed.

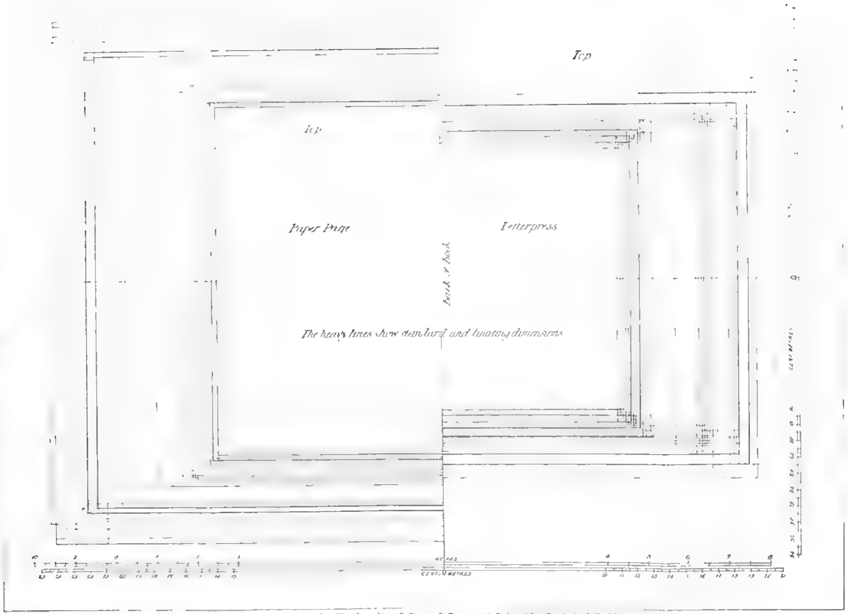
In the second experiment 'no paper was wrapped round the bulbs, but the brass dust was continuous from the bulbs to the sides of the iron pipe.' At the depth of 2,733 ft. an obstruction was encountered which prevented the tube from going lower, and which also caused the suspending wire to kink and break. After an immersion of about twenty-seven hours, the wire was successfully grappled, and the tube brought to the surface. 'The upper cap-piece was then rapidly heated in a chafing dish of charcoal made of an old nail-can, with a hole cut out of the bottom just sufficiently large to admit of the upper end of the tube being passed up it, and oxygen gas from a compressed cylinder was blown through a Fletcher's blowpipe on to the charcoal, so that in less than half a minute the solder in the threads of the cap-piece was melted; the lower portion of the tube containing the thermometers being meanwhile wrapped in wet cloths to prevent the heat travelling downwards. The cap-piece having been unscrewed and the thermometers withdrawn, the highest temperature registered was found to be 97° F.' 'Not a drop of water had found its way into the tube.'

On the following day the experiment was repeated, no wire being used for lowering, but only tarred rope; and sheet lead was wrapped round the tube to increase the weight. The tube was left down for one hour, and the maximum temperature registered was 96° F. The difference of 1° below the former observation is what might fairly be expected from the stirring of the water and the thermal capacity of the sheet lead which, with the tube, weighed 30 lb. The first result, 97° F., is therefore adopted as the true temperature at the depth of 2,733 ft. The mean surface temperature, as determined by Mr. H. C. Russell, is 63° F., giving an increase of 34° in 2,733 ft., which is at the rate of 1° F. for 80 ft.

As regards the possibility of disturbance of temperature by convection, Professor David mentions in a letter to the Secretary that the bore was only four inches in diameter. He also says, 'You understand, of course, that we can do nothing in the way of taking temperatures in a diamond-drill bore until the bore is quite completed, owing to the chilling of the rock at the sides of the borehole by the cold water which is being constantly forced to circulate under pressure through the bore.'

The temperature of the water of Port Jackson at the greatest depths near Cremorne, varying from 45 to 63 ft., was found (on December 6, 1893) to be uniform at 68° F. As this temperature is higher than that of the ground at the same level, no cooling effect can be attributed to the water. The slow rate of 1° F. per 80 ft., deduced from the observations, would therefore appear to be a good approximation to the truth.

It is expected that shafts will shortly be sunk at Cremorne, and will afford opportunity for the systematic observation of rock temperatures from the surface to a depth of nearly 3,000 ft. 'The first 1,000 ft. will be in horizontally bedded sandstone, and the remainder chiefly in clay shales, with interstratified sandstones and conglomerates.' The observations will be taken by Professor David and Mr. Pittman, with the



Illustrating the Report on the Uniformity of Size of Pages of Scientific Societies' Publications.

ON U

Committee's slow-action
shafts.
The Committee desi
valuable member, Mr. P

The Uniformity of Size
Report of the Com
(Chairman), Mr.
GLAZEBROOK, Dr.
(Secretary).

THE importance of ad
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a, *b*), and a somewh

Committee's slow-action thermometers, in holes bored in the sides of the shafts.

The Committee desire to express their regret at the loss of their valuable member, Mr. Pengelly.

The Uniformity of Size of Pages of Scientific Societies' Publications.—Report of the Committee, consisting of Professor S. P. Thompson *(Chairman)*, Mr. G. H. Bryan, Dr. C. V. Burton, Mr. R. T. Glazebrook, Dr. G. Johnstone Stoney, *and* Mr. J. Swinburne *(Secretary)*.

[PLATE I.]

The importance of adopting one or two uniform standard sizes for the pages of scientific publications will be evident to all specialists who have collected reprints of papers on any branch of science, and who have endeavoured to have them bound into volumes. Such collections are of more than passing interest, and they might, with advantage in many cases, be handed down to posterity as records of work in any particular subject, and it is, therefore, of importance that they should not be spoiled by the omission of one or two papers whose size precludes them from being bound up with the rest.

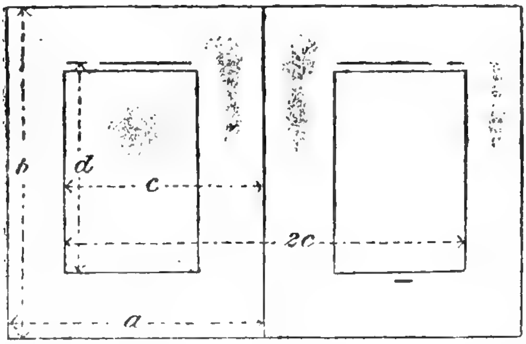
The Committee have thought it advisable in their first year to confine their attention chiefly to reporting on the size of the pages of existing mathematical and physical publications, and to deciding on what sizes to recommend as standards. In the latter matter they have been largely guided by the consideration that uniformity has been already to some extent attained, and this report will show that the desired results can be accomplished without making any radical changes in the sizes of the principal journals, and, indeed, without altering most of them at all.

In deciding whether two papers can or cannot be bound together, the size of the margin is quite as important a factor as the size of the paper. Thus the 'Bulletin of the New York Mathematical Society' is more than a centimetre wider and two centimetres higher than the 'Report of the British Association,' and yet if it were cut down to the same size it would still have exactly the same margin at the sides, and 6 mm. more margin at the top and bottom of the pages. Again, the 'Proceedings of the Physical Society' are printed with the same type as the 'Philosophical Magazine,' although one is medium and the other demy octavo. Hence arises the necessity of taking an internal measurement of the space occupied by the letterpress, as well as an external measurement of the size of the paper page.

This may be estimated as in fig. 1, which represents the opened pages of a book. a, b denote the width and depth of a paper page, c is the distance from the outside edge of the letterpress to the back, and d is the distance from the top of the running headline or number of the page to the bottom of the last line of letterpress, exclusive of the 'signature.' Hence $a-c$ is the margin at the side of the page, and $b-d$ is the sum of the margin at the top and bottom, so that if these are equal each is equal to $\frac{1}{2}(b-d)$.

By adopting a minimum limit for the size of the pages (measured by a, b), and a somewhat smaller maximum limit for the internal measurements c, d, we shall secure that all papers can be bound together without cutting the margin down below a certain limit. In fixing the limits we must allow for a little of the margin being cut away in binding.

Fig. 1.



Octavo Publications.—In the octavo sizes, the diagram, Plate I., shows an overwhelming preponderance of medium and demy octavo, the demy size being not only in the majority in point of number, but also including many of the most important publications. The royal octavo size recently proposed by the Royal Society is only represented by about two journals, of which the 'Proceedings of the Royal Artillery Institution' is one. On the other hand, the space occupied by the letterpress, as shown by the measurements c, d, is no greater in several of the medium size than in the majority of demy octavo, and there would, therefore, be no difficulty in cutting these down in binding. The Committee, therefore, recommend the following sizes :—

Standard Octavo Size.—Paper *demy*, the pages measuring 14 cm. × 22 cm., or, when uncut, $5\frac{5}{8}$ in. × $8\frac{3}{4}$ in. The width c, measured from the stitching to the edge of the printed matter to be 12 cm., or $4\frac{5}{8}$ in., and the height, d, of the printed portion including the running headline, to be 18 cm., or 7 in.

Limit of Octavo Size.—The paper page not to be less than 14 cm. × 21·5 cm., or $5\frac{1}{2}$ in. × $8\frac{1}{2}$ in., and the letterpress not to exceed the measurements c=12·5 cm., or $4\frac{7}{8}$ in., d=18·5 cm., or $7\frac{1}{4}$ in. Reprints and unbound numbers of journals to be issued with their edges uncut, or cut not more than 0·25 cm., or $\frac{1}{8}$ in., all round.

The use of standard as well as limiting sizes will easily be understood. Where publications fall within the limiting size there is little or no need for the size of the pages to be altered at present ; but when any alteration is made in the size, or in the case of new journals or papers printed by their authors for private circulation, it would be desirable to conform exactly to the standard size, which would ultimately become general.

Taking, first, the limiting sizes, and allowing for 0·25 cm., or $\frac{1}{8}$ in., being cut off the margins in binding into volumes, the pages of these would measure 13·5 cm. × 21 cm., or $5\frac{3}{8}$ in. × $8\frac{1}{4}$ in., and this would allow of a margin of not less than 1 cm., or $\frac{1}{2}$ in., all round, which is quite enough.

If the standard sizes should become generally adopted the bound and cut volumes would measure the same, and the margin would be 2 cm., or $\frac{3}{4}$ in., at the sides, and 1·6 cm., or $\frac{5}{8}$ in., at the top and bottom.

In the diagram it will be seen that there are journals which do not fall within the limiting dimensions. Where a and b fall short of the limits this could be remedied in some cases by leaving the edges uncut. Where c is too large, the letterpress could be brought a little nearer the stitching in imposing for press ; where d is too great, the pages could be shortened by a line or two.

Quarto Publications.—The corresponding dimensions for the principal quarto publications are given in the same diagram. Here, again, we find medium quarto (24 cm. × 30 cm., or $9\frac{1}{2}$ in. × 12 in.) and demy quarto

(22 cm. × 28·5 cm., or $8\frac{3}{4}$ in. × $11\frac{1}{4}$ in.) almost universal, but the preponderating sizes approach most nearly to demy, and on account of the large margins of many journals this is the most convenient size of the two, besides making the volumes less unwieldy. The Committee, therefore, recommend, in cases where it is desired to retain the quarto size, the following measurements :—

Standard Quarto Size.—Paper *demy*, the pages measuring, when uncut, 22 cm. × 28·5 cm., or $8\frac{3}{4}$ in. wide × $11\frac{1}{4}$ in. high. Reprints and unbound numbers of this size to be uncut, or cut 0·25 cm., or $\frac{1}{8}$ in. Measurements of letterpress to be c=18·5 cm., or $7\frac{1}{4}$ in., d=21·5 cm., or $8\frac{1}{2}$ in.

Limits of Quarto Size.—Paper pages not to measure less than 21·5 cm., or $8\frac{1}{2}$ in., wide × 28 cm., or 11 in., high. Letterpress not to exceed the measurements c=19 cm., or $7\frac{1}{2}$ in., d=23 cm., or 9 in.

The same remarks as to the advantage of standard and limiting sizes apply as in the case of the octavo. Allowing for 0·25 cm., or $\frac{1}{8}$ in., being cut off in binding, the limiting sizes will allow of a margin of not less than 2 cm., or $\frac{7}{8}$ in., all round, while the standard size will give a margin of 3·25 cm., or $1\frac{1}{4}$ in., at the sides, and 2·5 cm., or 1 in., at the top and bottom.

PLATES often get sadly mutilated when different papers are bound together, and sometimes this even happens when a volume of any periodical is bound up. Where they are folded over they not infrequently get cut in two by the guillotine. To avoid this the Committee recommend that the dimensions of the illustrations should never exceed 13 cm. × 20 cm., or $5\frac{1}{8}$ in. × $7\frac{3}{4}$ in., for octavo plates, and 21 cm. × 25 cm., or $8\frac{1}{4}$ in. × 10 in., for quarto, the width being measured from the back of the book. Where plates have to be folded, the fold should be 12·5 cm., or 5 in., from the stitching in octavo, and 20·5 cm., or $8\frac{1}{8}$ in., in quarto papers. Any folding plate should, when referred to elsewhere than in the opposite page of letterpress, have a blank space equal to the breadth of the paper page at the left hand, so that when open it can be referred to without closing the portion of the book being read that refers to it. This should be carried out even when the diagram or plate would not otherwise have to be folded, in order to reduce the trouble of reference.

Each article should begin a page. If possible it should begin a right-hand page. It is then possible to bind up any article with others on the same subject without having also to bind up the last half page of another paper. This difficulty can be overcome to some extent by splitting the paper. The pages of some of the journals abstracted in the 'Proceedings of the Physical Society' are split, one side being sent to each abstractor.

Comparison of Magnetic Standards.—Interim Report of the Committee, consisting of Professor A. W. RÜCKER (*Chairman*), Mr. W. WATSON (*Secretary*), Professor A. SCHUSTER, and Professor H. H. TURNER, *appointed to confer with the Astronomer Royal and the Superintendents of other Observatories with reference to the Comparison of Magnetic Standards, with a view of carrying out such Comparison.*

PROFESSOR RÜCKER and Mr. Watson have carefully compared three Kew-pattern magnetometers in order to investigate the causes of the discrepancies between the measurements of declination made with them. They find that if the greatest care be taken in the manufacture of the wooden box and the metallic adjuncts which are close to the magnet the discrepancies disappear.

In other words, the cause of the difficulty, in these three instruments at all events, is, not the metal base, but the much smaller masses of metal which are nearer to the magnet.

The three magnetometers are now in good accord.

A week has been spent at each of four observatories for the purpose of comparing one of these magnetometers and a dip-circle with the observatory instruments. Professor Rücker made the observations at Kew and Falmouth ; Mr. Watson, those at Stonyhurst and Valentia.

The greater part of the work which the Committee undertook has thus been accomplished.

It is still necessary to compare the instruments again with the instruments at Kew to ascertain that they are unaltered by transfer from one place to another; and as a new magnet-house is about to be built at Greenwich, it has been thought better to postpone the comparisons at that observatory until the house is ready for use.

The reductions of the observations which have been made are not yet finished. A full report will be made when the work is completed.

The Committee therefore ask to be reappointed, but no further grant is required.

The Application of Photography to the Elucidation of Meteorological Phenomena.—Fifth Report of the Committee, consisting of Mr. G. J. SYMONS (*Chairman*), Professor R. MELDOLA, Mr. J. HOPKINSON, *and* Mr. A. W. CLAYDEN (*Secretary*). (*Drawn up by the Secretary.*)

IN the report which the Committee presented last year, it was proposed that an agreement should be entered into with the London and South-Western Railway Company for the use of a site on their land, in order to carry out some measurements of cloud altitudes by means of photography.

This has been done. The cameras have been placed in position, and almost the whole time at the disposal of the secretary for such purposes has been spent in perfecting the electrical connection for releasing the two shutters simultaneously. Considerable trouble has been experienced in doing this. The apparatus, which worked admirably over a short distance, proved unreliable over the greater distance (200 yards) at present adopted. The agreement with the railway company provides that the connecting wire shall be removed when not in actual use, thereby necessitating as light a wire as can be made to suffice, which of course implies a considerable resistance. The result is that a more sensitive electric detent is required for the shutters, especially as it seems not unlikely that the distance may have to be increased by another 100 yards when the measurement of the highest varieties of cloud is attempted. This is still engaging the attention of the secretary to the Committee.

Some observations have been made, but although they confirm the belief that the method will prove valuable they have not yet been reduced to actual measurements. It should be remembered that the method is only applicable to those varieties of cloud which are visible at the same time as the sun, and that the opportunities of making observations cannot

FIG. 1.—Line from two slits. The gap is an interval of one hour.

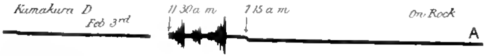


FIG. 2.—Line from broad slits, shows the unfelt earthquakes on Feb. 3. An earthquake which was felt ought to be at A.

FIG. 3.—Daily curves on surface. Instrument A.

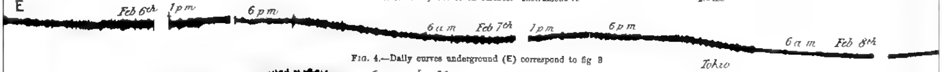


FIG. 4.—Daily curves underground (E) correspond to fig. 3.

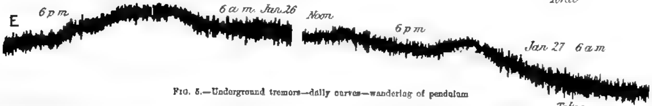


FIG. 5.—Underground tremors—daily curves—wandering of pendulum.

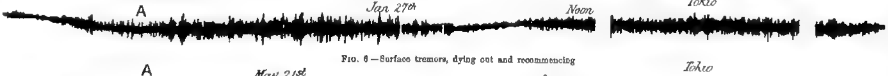


FIG. 6.—Surface tremors, dying out and recommencing.

FIG. 7.—Curve and tremors produced at the time a well was emptied.

*** *All gaps at or near noon represent an interval of one hour.*

EXAMPLES OF RECORDS FROM HORIZONTAL PENDULUMS.

Illustrating the Fourteenth Report of the Committee on the Earthquake and Volcanic Phenomena of Japan.

coincide with the possibility of making them, very frequently in the course of a short time such as that which has elapsed since the cameras have been finished.

Your Committee, therefore, ask to be reappointed for another year, so that they may carry out the work in hand, and with that object in view ask for a further grant of 15*l.*

Solar Radiation.—Eleventh Report of the Committee, consisting of Sir G. C. STOKES (*Chairman*), Professor A. SCHUSTER, Mr. G. JOHNSTONE STONEY, Sir H. E. ROSCOE, Captain W. DE W. ABNEY, Mr. C. CHREE, Mr. G. J. SYMONS, Mr. W. E. WILSON, *and* Professor H. MCLEOD, *appointed to consider the best Methods of Recording the Direct Intensity of Solar Radiation.*

THE Committee regret to have to report that for various reasons no experiments have been made with the Balfour Stewart actinometer since the last meeting of the Association. As Mr. Wilson has undertaken to continue the experiments, the Committee ask for reappointment and for the unexpended balance of the previous grant.

Investigation of the Earthquake and Volcanic Phenomena of Japan. Fourteenth Report of the Committee, consisting of the Rt. Hon. Lord KELVIN, *Pres. R.S.*, Professor W. G. ADAMS, *F.R.S.*, Mr. J. T. BOTTOMLEY, *F.R.S.*, Professor A. H. GREEN, *F.R.S.*, Professor C. G. KNOTT, *F.R.S.E.*, *and* Professor JOHN MILNE, *F.R.S.* (*Secretary*). (*Drawn up by the Secretary.*)

[PLATES II–IV.]

CONTENTS.

I. THE GRAY-MILNE SEISMOGRAPH.

THE first of this form of seismograph, constructed in 1883, partly at the expense of the British Association, still continues to be used as the standard instrument at the Central Observatory in Tokio.

I am indebted to Mr. K. Kobayashi, the Director of the Observatory for the following table of its records :—

Catalogue of Earthquakes recorded at the Central Meteorological Observatory in Tokio between April 19, 1893, *and May* 17, 1894

No.	Month	Day	Time	Duration	Direction	Maximum Period and Amplitude of Horizontal Motion		Maximum Period and Amplitude of Vertical Motion		Nature of Shock
						secs.	mm.	secs.	mm.	
					1893.					
			H. M. S.	M. S.						
1,322	IV.	19	11 25 25 P.M.	—	—	slight		—	—	—
1,323	,,	21	7 10 57 P.M.	1 0	—	2	2	—	—	quick
1,324	,,	26	10 0 46 A.M.	—	—	—	—	—	—	—
1,325	,,	30	11 32 19 A.M.	—	E.-W.	—	—	—	—	—
1,326	V.	1	2 5 6 A.M.	—	—	—	—	—	—	—
1,327	,,	11	4 52 33 A.M.	—	E.-W.	—	—	—	—	quick
1,328	,,	14	8 57 14 A.M.	—	—	—	—	—	—	—
1,329	,,	17	9 56 44 A.M.	—	—	—	—	—	—	—
1,330	,,	18	3 32 38 P.M.	—	—	—	—	—	—	—
1,331	,,	21	9 10 40 A.M.	—	—	—	—	—	—	—
1,332	,,	24	7 0 31 A.M.	—	—	—	—	—	—	—
1,333	,,	,,	8 58 57 P.M.	1 30	E.-W.	—	—	—	—	slow
1,334	,,	28	7 24 55 P.M.	—	—	—	—	—	—	—
1,335	,,	30	0 10 2 A.M.	—	—	—	—	—	—	—
1,336	VI.	4	2 27 17 A.M.	0 3	E.-W.	—	—	—	—	slow
1,337	,,	,,	9 7 38 A.M.	—	—	—	—	—	—	—
1,338	,,	,,	11 2 31 A.M.	0 1	N.N.W.-S.S.E	0·4	0·6	—	—	quick
1,339	,,	9	2 53 27 A.M.	—	—	—	—	—	—	—
1,340	,,	,,	4 48 41 P.M.	—	—	—	—	—	—	—
1,341	,,	10	8 6 44 A.M.	—	—	—	—	—	—	—
1,342	,,	12	4 8 0 A.M.	1 50	W.N.W.-E.S.E.	0·5	0·8	—	—	quick
1,343	,,	13	7 44 16 P.M.	3 50	N.-S.	1·2	5·0	—	—	slow
1,344	,,	18	7 19 10 P.M.	—	,,	—	—	—	—	—
1,345	,,	21	0 35 21 A.M.	—	—	—	—	—	—	—
1,346	VII.	5	9 52 42 P.M.	—	—	—	—	—	—	—
1,347	,,	6	8 9 52 P.M.	—	—	—	—	—	—	—
1,348	,,	18	5 45 6 A.M.	—	—	—	—	—	—	—
1,349	,,	19	8 38 23 P.M.	2 30	E.-W.	0·9	4	—	—	slow
1,350	VIII.	2	6 25 54 A.M.	—	—	—	—	—	—	—
1,351	,,	20	0 28 27 P.M.	0 4	N.N.W.-S.S.E.	0·5	3·6	0·3	1	quick
1,352	,,	22	9 37 55 A.M.	2 30	—	1·1	0·7	—	—	slow
1,353	IX.	4	5 7 30 A.M.	2 30	N.N.E.-S.S.W.	1·0	0·7	—	—	,,
1,354	,,	10	5 0 22 A.M.	—	—	—	—	—	—	—
1,355	,,	15	9 38 47 A.M.	—	—	—	—	—	—	—
1,356	,,	,,	6 28 22 P.M.	—	—	—	—	—	—	—
1,357	IX.	17	9 56 41 A.M.	—	—	—	—	—	—	—
1,358	,,	,,	1 39 31 P.M.	—	—	—	—	—	—	—
1,359	X.	6	7 11 51 A.M.	—	—	—	—	—	—	—
1,360	,,	10	8 27 21 P.M.	—	—	—	—	—	—	—
1,361	,,	19	0 57 17 A.M.	—	—	—	—	—	—	—
1,362	XI.	13	10 52 55 P.M.	—	—	—	—	—	—	—
1,363	,,	15	9 41 23 A.M.	1 4	E.-W.	0·9	0·3	—	—	quick
1,364	,,	28	1 15 29 A.M.	—	—	—	—	—	—	—
1,365	XII.	29	11 33 57 A.M.	1 8	N.E.-S.W.	0·5	0·9	—	—	quick
					1894.					
1,366	I.	4	1 37 20 P.M.	0 55	E.-W.	0·8	0·5	slight		quick
1,367	,,	10	6 5 4 P.M.	—	—	—	—	—	—	—
1,368	,,	,,	6 46 23 P.M.	3 15	E.-W.	—	—	—	—	slow
1,369	,,	12	2 50 33 A.M.	—	—	—	—	—	—	—

CATALOGUE OF EARTHQUAKES—*continued.*

No.	Month	Day	Time	Duration	Direction	Maximum Period and Amplitude of Horizontal Motion		Maximum Period and Amplitude of Vertical Motion		Nature of Shock
						secs.	mm.	secs.	mm.	
			H. M. S.	M. S.						
1,370	I.	16	5 29 40 A.M.	—	—	—	—	—	—	—
1,371	”	18	3 45 21 P.M.	0 48	E.-W.	1·0	0·4	—	—	slow
1,372	”	25	10 48 11 A.M.	—	—	—	—	—	—	—
1,373	II.	2	7 1 14 P.M.	—	E.-W.	—	—	—	—	—
1,374	”	16	2 0 53 P.M.	—	—	—	—	—	—	—
1,375	”	18	11 36 40 P.M.	—	—	—	—	—	—	—
1,376	”	20	8 29 3 A.M.	4 20	E.-W.	1·6	5·1	slight		slow
1,377	”	24	9 33 54 P.M.	0 55	N.N.W.-S.S.E.	0·7	0·7	—	—	—
1,378	”	25	4 17 42 A.M.	3 40	N.-S.	1·2	0·8	—	—	—
1,379	”	27	0 53 0 P.M.	2 21	E.-W.	1·4	2·4	slight		quick
1,380	”	”	10 51 39 P.M.	—	—	—	—	—	—	—
1,381	III.	3	10 20 9 P.M.	1 19	N.N.E.-S.S.W.	1·1	0·3	—	—	slow
1,382	”	5	11 0 38 A.M.	1 0	N.E.-S.W.	0·7	0·3	slight		”
1,383	”	6	8 29 30 A.M.	—	—	—	—	—	—	—
1,384	”	10	8 38 53 P.M.	—	—	—	—	—	—	—
1,385	”	12	4 8 1 P.M.	—	—	—	—	—	—	—
1,386	”	13	7 28 38 P.M.	—	—	—	—	—	—	—
1,387	”	14	8 59 57 A.M.	—	—	—	—	—	—	—
1,388	”	”	6 18 11 P.M.	—	—	—	—	—	—	—
1,389	”	16	2 54 18 A.M.	—	—	—	—	—	—	—
1,390	”	20	11 33 53 P.M.	—	—	—	—	—	—	—
1,391	”	21	3 9 10 P.M.	—	—	—	—	—	—	—
1,392	”	22	2 29 9 P.M.	—	—	—	—	—	—	—
1,393	”	”	2 38 42 P.M.	—	—	—	—	—	—	—
1,394	”	”	7 7 19 P.M.	—	—	—	—	—	—	—
1,395	”	”	7 27 49 P.M.	0 10	—	3·6	5·3	slight		slow
1,396	”	”	7 48 53 P.M.	1 0	N.-S.	—	—	—	—	”
1,397	”	”	10 6 16 P.M.	—	—	—	—	—	—	—
1,398	”	”	11 58 45 P.M.	—	—	—	—	—	—	—
1,399	”	23	0 45 54 A.M.	—	—	—	—	—	—	—
1,400	”	”	3 49 39 A.M.	—	—	—	—	—	—	—
1,401	”	26	2 36 12 A.M.	—	—	—	—	—	—	—
1,402	”	”	4 12 12 A.M.	—	—	—	—	—	—	—
1,403	”	29	6 0 27 P.M.	—	—	—	—	—	—	—
1,404	IV.	1	11 29 38 A.M.	—	—	—	—	—	—	—
1,405	”	2	5 31 3 A.M.	—	—	—	—	—	—	—
1,406	”	4	8 57 25 P.M.	—	—	—	—	—	—	—
1,407	”	7	7 7 10 P.M.	—	—	—	—	—	—	—
1,408	”	12	10 13 40 P.M.	—	—	—	—	—	—	—
1,409	”	14	2 39 30 A.M.	—	—	—	—	—	—	—
1,410	”	”	3 34 32 A.M.	2 40	E.S.E.-W.N.W.	0·6	1·3	0·4	1·0	quick
1,411	”	15	1 51 5 A.M.	—	—	—	—	—	—	—
1,412	”	17	3 54 52 P.M.	—	—	—	—	—	—	—
1,413	”	25	9 21 57 A.M.	2 18	E.-W.	1·2	0·5	—	—	slow
1,414	”	28	1 23 49 A.M.	—	—	—	—	—	—	—
1,415	V.	2	11 26 39 P.M.	—	—	—	—	—	—	—
1,416	”	4	10 51 55 A.M.	—	—	—	—	—	—	—
1,417	”	6	6 3 22 P.M.	—	—	—	—	—	—	—
1,418	”	10	4 11 39 A.M.	2 50	N.N.E.-S.S.W.	0·7	0·5	—	—	slow
1,419	”	16	5 52 45 P.M.	—	—	—	—	—	—	—
1,420	”	17	6 1 29 A.M.	—	—	—	—	—	—	—

Remarks.

Shock 1,351.—Commenced very gently for about 36 seconds, when a violent shaking, lasting 16 seconds, took place. It then died out.

Shock 1,352.—This commenced gently for 32 seconds, after which, for 9 seconds, the motion was strong. Then it died out.

Shock 1,366.—Strong motion, lasting 15 seconds, commenced after 9 seconds of preliminary motion.

Shock 1,368.—Was very slow and gentle. After one minute the horizontal motion was marked for about 13 seconds. During 26 seconds it showed nineteen large waves.

Shock 1,376.—At first this was slow, but became stronger after 3 minutes 12 seconds, when for the next 30 seconds it was pronounced.

II. Observations with Horizontal Pendulums.

In the years 1883, 1884, 1885, 1887, 1888, 1892, and 1893 I embodied in Reports to the Association some account of work which had been carried out in Japan in the investigation of earth tremors or pulsations and earth tilting. The Twelfth Report (1892) describes a pair of extremely light horizontal pendulums the movements of which were recorded on photographic plates or films, and gives some account of the analysis of the resulting records. The observations were continued during the following year, and, as stated in the Thirteenth Report (1893), it was observed that the direction of earth-tilting movement and also of earthquake movement in the majority of cases coincided with the direction in which strata have been folded to form mountain ranges bordering the Tokio plain. Another observation was that certain earthquakes had been preceded by an abnormal amount of tilting.

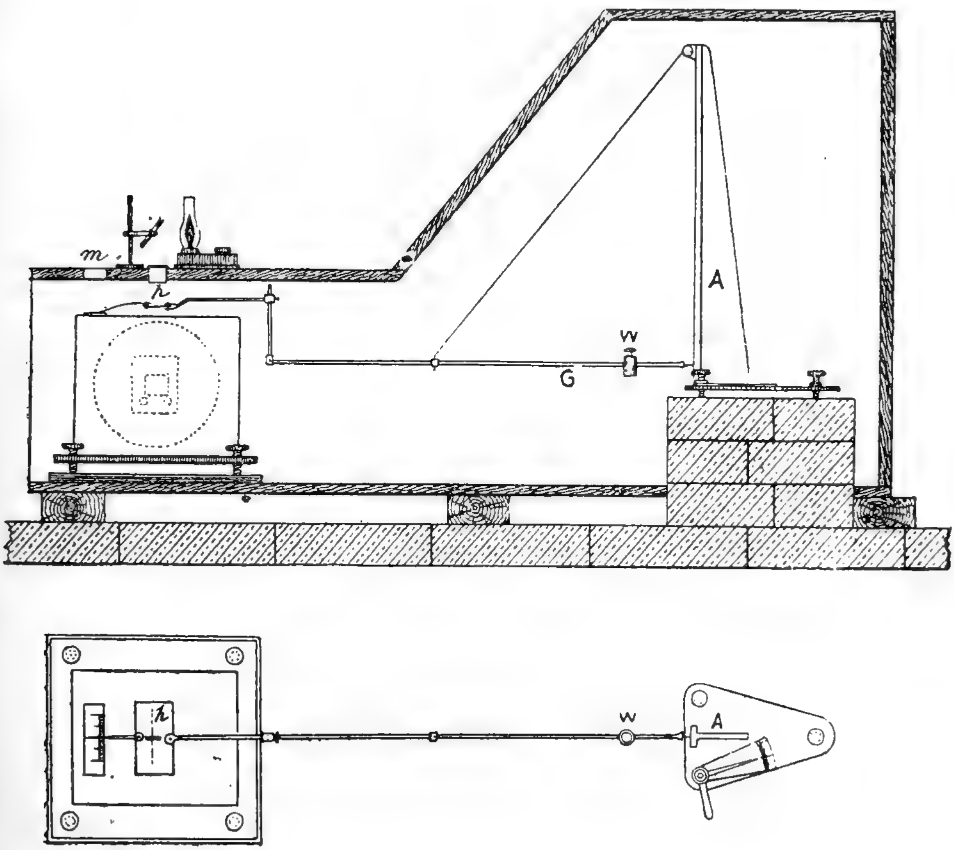
In consequence of the liberality of the Royal Society of London during the last year I have been enabled to extend these observations, using six horizontal pendulums, each provided with photographic recording apparatus.

The places of observation have been in Tokio, at my house, on a massive stone column, and at a place about 1,000 feet distant in an underground chamber on a concrete bed; at Kanagawa, in an artificial cave driven in a soft tuff rock at a depth of 50 feet below its junction with 50 feet of overlying alluvium; at Yokohama, in a cave driven at the junction of the tuff and alluvium; and at Kamakura, in a cave in the tuff which at this place is hard and dips at an angle of 30° N.E. All these places lie from Tokio on a S.S.E. line, and are respectively 20, 23, and 38 miles distant from my house. At Kanagawa and at my house there is only one instrument, and the booms of these pendulums point N.W. At the other stations two instruments have been or are now being used, and these are placed at right angles to each other, one pointing N.W., or parallel to the strike of the rocks, and the other N.E., or parallel to the dip. At Kamakura observations were made for two and a half months, when the instruments were brought to Yokohama. At this latter place, owing to a series of accidents, one of which was the collapse of the roof of the cave, up to the present the observations have been extremely few. At Kanagawa, although the cave is wet, the observations have been fairly continuous. In Tokio, where I am able to see the instruments every day, but few interruptions have occurred. The chief part of this report, therefore, refers to Kamakura and Tokio.

(a) *The Instruments.*

Although pendulums made of pieces of aluminium wire and held up with quartz fibres with their mirrors and lenses have given excellent results, the apparatus required good installation and careful manipulation. As these requirements were not obtainable, excepting in Tokio, before commencing observations in the country my first task was to design an instrument of a simple character, not easily put out of order, and which would give continuous records for at least one week. This was done, and as the six instruments which have been made have worked satisfactorily I give the following description of one of them.

FIG. 1.



The pendulum stand A, fig. 1, with its upright, which is 50 cm. high, is of one piece of cast iron.[1] The distance between the levelling screws working in brass sockets is 23 cm. The back screw tilts the upright and gives the required degree of stability to the pendulum ; one of the lateral screws is used in adjusting and calibrating the pendulum. It carries a pointer moving over a graduated arc. By turning it, for example, one degree, which means raising this corner of the instrument $\frac{1}{360}$ of a millimetre (the

[1] The form of the bed-plate is that of a right-angled triangle with the right angle near A.

screws having a millimetre pitch), the corresponding deflection of the pendulum may be noted. The turning is done by a lever projecting from the head of the screw.

The boom of the pendulum is an aluminium tube 4 feet (120 cm.) in length, carrying a sliding weight, W, and a movable point to which the supporting tie can be attached. This tie, which is of thin brass wire, at its upper end terminates with about an inch of untwisted silk. On the inner end of the boom there is a quartz cup which bears on a steel needle projecting slightly upwards from the base of the cast-iron stand. The suggestion that the needle should project from the stand rather than from the boom is due to Dr. von Rebeur-Paschwitz. It gets over the difficulty of having anything which may be markedly magnetic in motion; and secondly, in case of violent disturbance, the relative verticality of the points of support is less liable to alteration.

The instrument is adjusted so that the needle bears normally on the centre of the quartz cup, or so that the centre of gravity of the system falls about G.

At the outer end of the boom a stiff wire rises vertically upwards. Clamped to this at the required height is a horizontal wire 15 cm. long, carrying a thin zinc plate *p*, measuring 6 cm. by 10 cm. In the centre of this, and parallel to the length of the boom, there is a slit about 0·5 mm. broad and 2 cm. long. As the boom moves to the right and left, this slit floats over a second slit about 5 cm. long in the lid of the box covering the drum which carries the recording paper. These two slits are at right angles to each other, so that the light from a lamp reflected downwards by a plane mirror only reaches the drum as a spot.

A well-defined spot, which means a clear, sharp line on the photographic film, can be obtained without fine adjustment. That is to say, the distance between the film and the slit, or between the stationary and moving slits, may be anything between 1 and 5 mm. Projecting an inch or so beyond the moving plate and attached to it is a pointer moving over a scale fixed on the cover of the box containing the clock of the recording drum. This can be inspected and the position of the boom at any time noted by looking through the glass plate at *m*.

The recording drum, on which the photograph-paper is fixed with a spring clamp, as in a recording barometer, is of thin sheet brass 5 cm. wide and 105 cm. in circumference (some are much less). It is turned at the rate of 15 cm. per 24 hours, and a film therefore lasts one week.

The clocks, which are an American type intended to run 8 days, have fitted to the slowest moving arbour four wheels, the last of which turns a disc with slots round its edges once a week. The recording drum, which can be dropped into its bearings, carries a large crank. When in position the clock is slid in a groove until one of the slots catches the outer end of the crank arm; after this the cover is put over the clock and drum, and the whole is pushed on grooves into the end of the case covering the pendulum.

Hollow wooden drums, which are easily driven by the clock-work, have a tendency to warp, and this may result in a want of uniformity in the motion.

Brass drums in the damp atmosphere of a cave in a month or so tend to rust, and this rust may act upon the photographic film to such an extent as to render it illegible.

Up to the present time ordinary kerosene lamps have been used, but as they require attention at intervals of from 8 to 12 hours they are being replaced by lamps such as are used in magnetic observations burning benzine.

Every day from 12 noon to 1 P.M. the lamps are removed and a reading is taken, so that time intervals are marked on the photographs and scale values are obtained.

It does not seem necessary that the boom should be made of aluminium, as I obtain what appear to be equally satisfactory records with booms of brass or even wood. The most delicate pendulum I have has a boom made of varnished bamboo with brass fittings. It is about 5 feet in length, and when last rated had a period of 55 seconds. I say last rated because I find that this pendulum, like all others I work with, changes its period, and therefore its sensitiveness, from week to week. I notice that this source of error when computing results is also found in the infinitely better constructed and better installed apparatus used by Dr. von Rebeur-Paschwitz.

When the pendulum has its 55-second period one millimetre deflection on the photographic plate is equivalent to a tilt of 0·08 second of arc. With this degree of sensitiveness a 14 lb. weight placed on the column, which is old and massive, at a distance of 2 feet from the instrument causes a deflection of 0·5 mm. My weight on the floor *at the outer end* of the boom produces no visible effect.

In this condition the pendulum is, however, often too sensitive, as it will, from time to time, wander an inch or so to the right or left of its mean position, and the spot of light fall outside the film. A sensitiveness of 1 mm. motion per 0″·5 arc is usually quite sufficient, and I do not think that apparatus like those of Wolf, d'Abbadie, Darwin, or von Rebeur-Paschwitz capable of recording tilting of from $\frac{1}{100}$ to $\frac{1}{300}$ of a second could be used on the alluvium of Tokio even when installed on a concrete bed underground.

Such apparatus might, however, be used on the solid rock which crops out round the Tokio plain.

An attempt to test the accuracy of one of the horizontal pendulums was made by placing it on an iron plate resting on a plank 18 in. broad, $1\frac{3}{4}$ in. thick, which in turn rested on supports near its end 6 feet apart. It was then adjusted, so that trials with the test screw indicated that turns of 10° gave an average deflection of 11·5 mm.

Side by side with the pendulum a transit instrument having a good telescope was placed, and this read on a scale fixed on a brick wall at a distance of 720 feet. The supporting plank was then loaded at its middle until the telescope showed a deflection of 14 in. on the scale and the pointer of the pendulum moved 93 mm. From this it seems that the pendulum indicated a tilt of 1 in 562, while the angular tilt of the telescope was 1 in 616.

These are the means of a series of experiments, and assuming that the readings through the telescope were correct, then the pendulum indications are about 10 per cent. below their true values. On the other hand, assuming that the readings through the telescope were one inch too small, and it was difficult to read within that quantity, then the pendulum indications are 2·3 per cent. short of their true value. A great source of error no doubt resides in the test screw of the pendulum.

The instrument described will be recognised by those engaged in similar investigations as coarse in construction, roughly approximate in its records, and because it is large as being in all probability subject to convection currents, unequal heating in its parts, and other interferences. In spite of these objections, I find it satisfactory. It is cheap, easily put up to read from 1″ to 0″·5, easily worked, while the light is near the film, and therefore in the best position to use with ordinary bromide paper.

With more delicate apparatus, on the Tokio plain at least, no matter what the size of the foundations might be, the results of my experiments show that such instruments continually require readjustment in order to keep the light on a film of manageable breadth, while if installed on the rocks in the mountains I fancy that, owing to earthquakes or the gradual yielding of the column, there would be a constant change in the meaning of the deflections. In two of my pendulums I notice that sometimes they gradually become more sensitive and sometimes less sensitive.

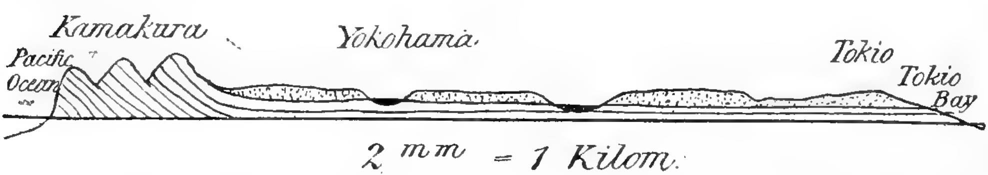
The columns I am using underground are of brick, 2 ft. high and 2 ft. square, put together with pure cement. On the top of these, at first, I placed a slab of marble; but because I noticed that in a damp atmosphere there was a marked chemical action taking place between the brass screws and the stone on which they rested, the marble has been replaced by slate.

(*b*) *Observations at Kamakura.*

Kamakura, one of the ancient capitals of Japan, lies on the western side of the Miura Peninsula, facing the Pacific Ocean. On account of its ancient temples and its enormous bronze Buddha it is visited by almost all travellers to Japan. The geologist has an interest in visiting this place, as it has been the site of a series of earthquakes, which, with their accompanying sea waves on more than one occasion, are said to have laid waste a city of a million people. The place is prettily situated amongst Tertiary hills which rise to heights of from 100 to 600 feet around the plain on which the ancient capital stood. The cliff-like faces of these hills show a series of conformable beds dipping about 30° N.E. These beds, which are soft grey coloured clay stones or beds of consolidated ashes, are from a few inches to a few feet in thickness, and are traversed by numerous small faults the throw of which, so far as I have observed, does not exceed six feet. Near to the temples, caves have been excavated, which are used as shrines; while similar but smaller caves have been made by farmers, and are used as storehouses.

The general relationship of the strata at Kamakura to the alluvium and diluvium overlying tuff at Yokohama and Tokio is shown in the accompanying section.

FIG. 2.



At Kamakura the tuffs are crushed and faulted, but before reaching Yokohama they pass into gentle folds, and then become horizontal and are capped with some fifty feet of reddish earth and gravel. This condition, with the exception that the overburden is perhaps 100 feet in thickness, continues up to Tokio.

At Yokohama the tuffs, which almost entirely consist of a light grey coloured clay rock, are visible as cliffs from 50 to 80 feet in height. In Tokio, however, they only crop out at one or two places at the bottom of deep cuttings. The depressions in the section represent the flood plains of rivers which are filled with soft alluvium.

Rather than working on strata which had been so far crushed and crumpled that further yielding is hardly to be expected, I should have preferred a site on the strata which are gently folded, and where a measurable amount of yielding may yet be in operation.

Although I had the choice of several caves as Kamakura, all of them were situated at some distance from the railway. To go and return from the one I selected took six hours, and it was therefore seldom that it was visited more than once a week. Very fortunately I received assistance from Mr. P. E. Heerman, a gentleman who happened to be staying in the neighbourhood, while one of the officials from the railway station kept the lamps burning, and three times a day took readings of the instruments. That the latter was attended to regularly was shown by a slight change in the intensity of the photographic trace at the times when the lamps were adjusted, a gap when they were removed to be refilled and a slight notch in the diagram from a self-recording thermometer at the times when the doors of the cave were opened, and the times at which these various marks were made coincided with the times at which the readings were noted as having been made.

The cave seems to have been excavated on the line of a fault which, curiously enough, is with difficulty recognisable on the face of the cliff itself, but which is quite apparent in a photograph. The entrance to the cave, which faces S.E., was, with the exception of the door, blocked up with a wooden wall faced on the outside with a bank of earth and rubble work 4 feet in thickness. The dimensions of the cave were 20 feet by 20 feet, with a height of from 7 to 10 feet. One corner of this was partitioned off with wooden walls to form a room 10 feet square, and from this the *débris* was cleared out to reach the solid rock on which two brick platforms were built.

These were one brick thick and laid with pure cement. On the end of each of these platforms, which were at right angles to each other—one running N.W. and the other N.E.—a small pillar three bricks high and one brick square was built and capped with a slab of marble. These were finished on January 7, and the cave was left open for one week to facilitate the drying. At the end of that time, on January 14, as the cement appeared to have set, the instruments were placed on the slabs and the records commenced. From that date, with but few interruptions continuous photographic traces were obtained until March 18. These machines I have called C and D. Machine C recorded tilting parallel to the strike, while D recorded movements parallel to the dip. By a lifting on the S.E. side the readings of the index attached to C increased in value, while the readings of D increased with a lifting on the S.W. side.

At the end of each week, when a photographic film was renewed, the sensitiveness of the instrument was determined, after which it was re-adjusted. These determinations are given in the following table. The ratio of unity to the numbers in the first two columns is the tangent of the angle through which the instrument would have to be tilted to produce a deflection on the photographic trace of one millimetre ; the corresponding angles in seconds of arc are given in the third and fourth columns. At the commencement it will be observed that to produce a deflection of one millimetre in C a tilt of about 2″ would be required. Between February 18 and 25 the same deflection was obtained by a tilt of about 0″·27. Because D recorded more motion than C, it is important to notice that this occurred notwithstanding the fact that on all occasions, excepting between February 4 and February 11, C was very much more sensitive than D.

Sensitiveness of C and D.

Date	C	D	C	D
Jan. 14–21	115,776	86,400	1″·78	2″·27
„ 21–28	313,560	250,560	0″·66	0″·82
„ 28–4	434,160	280,800	0″·48	0″·73
Feb. 4–11	313,560	355,600	0″·66	0″·58
„ 11–18	578,880	280,800	0″·35	0″·73
„ 18–25	771,840	280,800	0″·27	0″·73
„ 25–4	675,360	302,400	0″·30	0″·68
March 4–11	627,120	216 000	0″·32	0″·95
„ 11–18	482,400	259,200	0″·42	0″·79

The temperature variations in the cave during 24 hours never exceeded 1°·5 C.

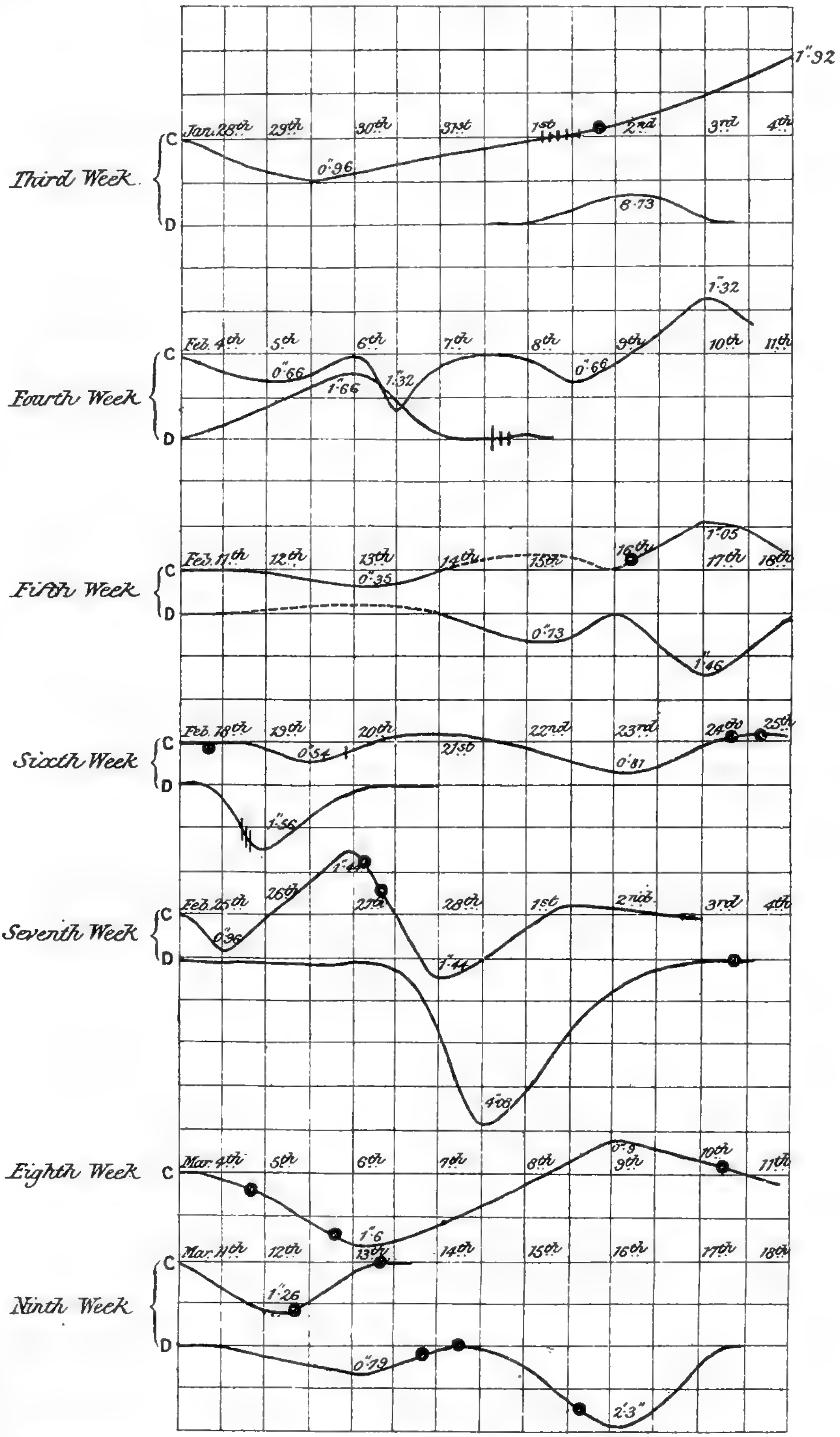
(c) *The Diagrams.*

At first sight, with the exception of places where earthquakes have been recorded, the photographic traces appear to be a series of long straight lines, and the fact that movements have taken place to the right and left of a normal position can in most cases only be seen by looking along their length (see fig. 2, Plate II.). The curves which are thus seen are too long and flat to admit of accurate measurement, and although the films had only moved at a rate of about 6 mm. per hour there is great uncertainty in determining points of inflection. For these reasons both the angular deflections and the periods occupied in describing them are only rough approximations. In the diagrams, Plate III., the observations extending over nine weeks are plotted as a series of curves. The vertical lines indicate noon and midnight of successive days, which are marked with their dates. The horizontal lines, which are 10 mm. apart, indicate seconds of arc. If the curve for C goes downwards from its starting point the movement is equivalent to a rising on the S.E. side, while if the D curve descends this means that the S.W. rises. The angular values for the various deflections are marked on the diagrams, while earthquakes recorded by seismographs but not by the pendulums are indicated by dots. Earthquakes recorded by the pendulums but not by seismographs are shown by short straight lines.

(d) *The Movements of the Pendulums.*

From the diagrams it is clearly seen that during any week the pendulums have once or twice wandered away from and then returned to their starting point. Because the movements or periods of comparative rest of the two instruments approximately coincide in time, as, for example, during the fifth week, I take it that the cause of these movements is something more general than a warping of the supporting columns. The movement of D or that which is parallel to the dip has usually been greater than that indicated by C or parallel to the strike. For example, it may be

Movement of horizontal pendulums at Kamakura.



Earthquakes recorded on the photographic trace .... |

Local earthquakes not recorded on the photographic trace .... ●

Illustrating the Fourteenth Report of the Committee on the Earthquake and Volcanic Phenomena of Japan.

imagined that between February 28 and March 3 the dip of the rocks increased and then decreased through an angle of 4″·08. *About* the same time the movement at right angles to this was 2″·88. With the exception of a wave indicated by C between February 6 and 7, which had a period of 24 hours, all the other movements have had periods of from 48 to 70 hours. In this respect the movements are strikingly different from those recorded in Tokio, where diurnal waves are very frequent. Another remarkable feature in the records is the entire absence of tremors, which in Tokio on the alluvium often result in producing a photographic trace from 5 to 10 millimetres, and sometimes even more than this, in breadth (Plate II., figs. 5 and 6). Although it is premature to offer an explanation for the Kamakura movements the following statement may be made. As the changes in temperature in the cave were usually too small to be measurable it is not likely that the wandering of the pendulums can be attributed to such a cause. Any effect that the heat of the sun may have had upon the face of the cliff in which the cave is situated, in raising its temperature or by withdrawing moisture from its surface, would probably be diurnal in its character. The only sunshine records which I have taken commence on February 25. From that day to February 28 there were 28 hours of sunshine which was followed by dull weather until March 11. Although the end of the period of sunshine was followed by a great movement, considerable movements occurred during the comparatively cloudy weather. Because the records are few this observation, however, carries but little weight. Rain, which only fell between February 8 and 9, and again between March 5 and 6, does not show any connection with the movements. Notwithstanding these observations, since the wandering of pendulums in Tokio, as will be shown later, is apparently connected with the movement of subterranean water, which in turn is related to percolation from the surface, it does not seem unlikely that the movements at Kamakura may also find a partial explanation in a somewhat similar cause. The only other explanation, which, however, has not yet been verified, is that they result from rock crumpling which is still in progress, and for this reason the greatest motion is parallel to the dip.

Conclusions of practical importance which I arrive at are that although pendulums which will record a tilting of 0″·3 are sufficiently sensitive to be used on the Tokio plain, an instrument of much greater sensibility is required to study movements on the rock, and, further, that all who have to carry out physical investigations requiring a steady platform will gain great advantage by installations on the rock where tilting is small and diurnal movements and tremors are not appreciable to instruments such as I have employed.

(*e*) *Earthquakes.*

The earthquakes which have been recorded by the Kamakura instruments in 1893 are as follows :—

The following 26 disturbances are clearly shown upon the photographic traces. In addition to these there are a number of slight irregularities with amplitudes of 1 mm., or under, which have been omitted, first, because they are very small, and secondly, because they might or might not be due to earth disturbances. While the observations were going on, that is, between January 14 and March 18, by means of seismographs in Tokio, 21 shocks were recorded. These were disturbances that were felt in Tokio, and it is known that several of them were also felt in Kamakura. It is probable

Month	Day	Time	Range of motion in mm.	Maximum tilting	Duration	Instrument on which recorded	Remarks
		hr. min.		secs.	hr. min.		
I.	18	3 46 P	15	30″·00 ?	2 10		Recorded in Tokio
	25	8 41 A	14	11″·48	0 10	D	C not working
	25	9 21 A	8	6″ 56	0 20	D	" "
	26	7 15 A ?	4	3″·28			
II.	1–2	Six slight disturbances					
	3	8 30 A	12	5″·76	0 45	C and D	D gives 8″·76
		10 00 A	6	2″·88	0 18	C and D	" " 4″·38
		10 50 A	13	5″·76	0 36	C and D	" " 8″·76
	4	7 0 A	Slight				
	5	7 18 A ?	2	1″·32			
		3 54 P	3	3″·30	0 9	C	
		4 03 P	5	3″·30		C	
	6	4 54 A	2	1″·32		C	
	8	2 50 A	12	6″·96	0 30	D	
		6 30 A	3	1″·74	0 10	D	
		6 50 A	4	2″·32	0 10	D	
	19	7 31 A	6	4″·38		D	
		8 00 A	6	4″·38		D	
		8 26 A	6	4″·38		D	
	20	8 30 A	5	1″·35		C	On D 4″·38 Recorded in Tokio
	27	12 50 A	7	2″·10		C	On D 4″·38. Recorded in Tokio

that had a seismograph been placed in Kamakura all these shocks and possibly a few others would have been recorded. The horizontal pendulums, however, have only recorded three of the Tokio series, and to the remaining 18 they have been insensible. On the other hand, they have recorded 23 disturbances which the Tokio seismographs have failed to record. Although I have not yet had time to fully analyse the records of earthquakes given by the Tokio pendulums, from what I have seen of them I know that the results will be similar. On many occasions I have watched a horizontal pendulum while a sharp disturbance lasting from 15 to 30 seconds has been taking place. All that happens is that there is a slight elastic switching in a vertical direction of the pointer at the end of the boom. The boom does not swing, and I have not observed a blurr in the photographic trace. (Plate II. fig. 2.) On the other hand, whenever an earthquake instead of simply producing elastic vibrations throws the surface of the ground into undulations, the pendulums behave most erratically. They do not swing, but they are forced first to one position and then to another. Now and then they may pause for two or three seconds, but only to start, perhaps, more vigorously than before. It is interesting to watch a seismograph writing an earthquake, but a horizontal pendulum actuated by earth waves is one of the most attractive sights that a seismologist can witness. When a seismograph is disturbed you feel the motion that causes it to move, and in two or three minutes all is ended; but when a horizontal pendulum is disturbed nothing is felt, and its spasmodic movements may continue for one or two hours. Fig. 3, p. 109, shows what is almost continuous motion for 5 hours 24 minutes. Already I have had the good fortune to see this phenomenon five times. On the last occasion, March 22, at 7.27 P.M., I sent a messenger to call my colleague, Mr. C. D. West, who arrived some 15 minutes later, when we watched the big boom stopping and starting from various positions for 1 hour 47 minutes. These waves had a submarine origin about 40 miles off the N.E. corner of Yezo, in about 43° N. lat. and 146° E long., and to reach Tokio had travelled some 570 miles. I think that they have been recorded in Rome, and I have written to Dr. E. von Rebeur-Paschwitz to learn whether they were noted at Potsdam, Wilhelmshaven, and Strassburg. They ought to have reached the Birmingham instrument about midday on March 22.

While I am writing in Sapporo (Yezo), on June 20, at 2.32 P.M., a terrible earthquake has happened in Yokohama and Tokio. As we are 9 hours E. of Greenwich this should be recorded at the above stations and those in Russia at about 6.30 A.M. on the same day.

From the manner a pendulum behaves I infer that its movements are due to the fact that it is being tilted, and because the photographic records are always less than the distances through which I have seen it move, the values given for the tilting are less than those which actually happened. If a pendulum is set swinging, for example, by standing near its column, through a distance of, say, 5 mm., it will come to rest in about 5 minutes. In calculating the duration of a disturbance allowance has been made for this factor.

The point of greatest importance in connection with the foregoing remarks is the inference that the catalogue of Kamakura earthquakes represents a series of large disturbances which have travelled very great distances. Had there been any local disturbances sufficiently great to produce earth-waves, then the pendulums must have recorded the same, but no such disturbances occurred. As it is not likely that earthquakes originating at a distance could in any way be connected with local tilting, if earthquakes and tilting have any connection those which might be compared with the curves already given are those of local origin which have been recorded by seismographs in the vicinity, and not those which are shown on the photographic films. Between January 24 and March 18 fifteen shocks were noted in Tokio, which cannot be seen on the photographic traces. Because nearly all these were of the nature of elastic vibrations it is probable that they were for the most part of local origin. This is a point which can only be definitely settled by analysing the reports accumulated at the Meteorological Bureau, which for various reasons cannot be done in time for the present report. These 15 shocks are indicated on the curves as black dots, and it is certainly worth observing that they chiefly occur during the seventh, eighth, and ninth weeks when tilting was marked. Because the observations are few and because I am not yet in a position to analyse all the materials which have been accumulated, too great stress should not be laid upon this last observation. It only indicates the nature of an inquiry that is being made.

The last point to which attention must be called in connection with the Kamakura disturbances is that the greatest motion has nearly always been in the direction of the dip, that apparently being the direction of least resistance to yielding. By reference to the catalogue it will be seen that there are three instances where small disturbances have only been recorded by C, but in all other cases the records are given by both instruments, the dip record being much the larger, or the record has been given by D alone. For example on February 8 D was tilted for 30 minutes through an angle of nearly 7″, while C did not show that any motion had taken place.

(*f*) *The Observations in Tokio.*

Although the observations made in Tokio were carried on at two stations, because these stations were only 1,000 feet apart, and because both were on the alluvium which here forms a layer perhaps 100 feet in thickness above the tuff rock, it was anticipated that the records would to some extent be similar in character. For this reason they are described together.

Machine A, which is similar to those used at Kamakura, is installed on a table-like stone column in my house. The column is 4 feet square and rises clear of the floor from a concrete bed. For a few hours in the morning and in the afternoon the sun produced a marked tilting as it shone upon the column through a window on the south side; on closing this window by a shutter on the outside and by a curtain on the inside, this effect disappeared, while the diagram from a self-recording thermometer occasionally showed during 24 hours a steady rise or a steady fall of 1° or 2° C. More usually, however, the diagram showed that from 9 or 10 A.M. until 5 or 6 P.M. there had been a rise of 4° or 5° C., after which the temperature fell until next morning. This is a point to be noted, because it will be shown that the daily tilting and, in a less marked degree, the intensity of a tremor storm have a similar periodicity.

The water level beneath my house oscillates above and below 36 feet.

Machines E and F, which are underground, only differ from A in the fact that their booms are brass tubes. Machines A and F are parallel to each other, and point N.W. Machine E is at right angles to A and F. With an increase in the readings of A or F the movement corresponds to a lifting of the ground on the N.E. side of these instruments. An increase in the scale readings of E corresponds to a tilting on the S.E. side.

The underground chamber is excavated on a flat piece of ground about 20 feet below the site of my house. It is 13 feet deep and 20 feet square. The floor is covered with $\frac{1}{2}$ in. of asphalt, which rests on a bed of concrete 6 in. thick, which in turn rests on a bed of well-rammed gravel. The walls and ceiling are brick with clay puddle on the outside. Above the chamber a wooden house has been built; the entrance is by double doors, and it is fairly well ventilated by gratings for the admission of air and a short iron chimney for its exit. The daily fluctuations in temperature in this underground room are practically zero, the diagram from a self-recording thermometer showing a straight line which at present indicates a steady rising of 1° C. per week. The water level in a well about 80 yards distant, where I have established a tide gauge, is about 25 feet below the surface. The floor of the chamber is therefore about 12 feet above water level, but it must be remembered that this level may rise and fall through 2 or 3 feet.

(*g*) *Sensitiveness of the Instruments.*

From time to time the sensitiveness of the instruments was determined, and if necessary they were readjusted.

The first column in the accompanying table indicates the number of millimetres through which the end of the boom travelled by a 1° turn of the sensitising screw in the bed plate, the pitch of the screw being 1 mm. One complete turn of the screw attached to A tilted the bed plate of this instrument through an angle of 1 in 228. For E and F one complete turn represented an angle of 1 in 222.

The ratio of unity to the numbers in the second and fourth columns is the tangent of the angle corresponding to a deflection of the boom through a distance of 1 mm., the values of these angles expressed in seconds of arc being given in the third and fifth columns.

	A		E and F	
2·5			199,800	1″·03
5			399,600	0″·51
6			479,520	0″·43
6·5			519,480	0″·39
10	820,800	0″·25	799,200	0″·26
10·5	861,840	0″·23		
11	902,880	0″·22	879,120	0″·23
12	984,960	0″·20		
13			1,038,960	0″·19
14			1,118,880	0″·18

To bring the points of E or F to the centre of the scale, a rough adjustment is made with the sensitising screw, after which the boom may be slightly moved to the right or left by means of a stone about 40 lb. in weight which I shift on the floor of the chamber towards or away from the instrument.

(*h*) *Daily Tilting.*

The approximate times at which the diurnal wave reached its maximum and minimum, and the amplitudes of these waves for dates between January 24 and March 1, 1894, are given in the table, p. 97. Should it be necessary the table may be completed from December 9, 1893, up to the middle of June 1894. With but few interruptions the records have been continuous. It will be observed that the records for F, which is parallel to A, are only one or two in number. The letter *s* means that the diurnal wave is too small to be measurable, while blank spaces indicate that it was not visible, the photographic trace being a straight line. Had greater sensibility been given to F it is quite possible that the daily wave would have been recorded; but this could not be done because, even with the stability it had during three days, the end of the boom often wandered through a distance greater than 1 inch, and the spot of light left the film. This wandering of the pendulums has been already referred to. On two occasions when F gave measurable waves (January 31 and February 2) the times of their occurrence approximately coincided with the movements of E and A—that is, the movement of the pendulums in one direction was reached in the evening, after which they gradually returned to reach their normal position in the morning. The pendulums E and A, although at right angles to each other, have shown a marked synchronism in their movements. It would seem that these two instruments have either been simultaneously acted upon by independent forces, or that they have recorded components of a common force, which has acted in different directions at the two stations.

The latter explanation appears to be the more satisfactory, because periods of steadiness when the diagrams were practically straight lines happened at the same time, and because the large or small movements of A have agreed in time with the large or small movements recorded by E. As illustrative of this synchronism, the movements of these instruments between February 15 and February 25 have been plotted as curves (see Plate IV.).

Once or twice it will be observed that crests of waves have been reached after midnight or in the morning, which agrees with the results published in 1893 (Thirteenth Report). In the majority of instances, however, this has been reversed, and the movement of the pendulum in one direction has been completed at any time between 4 P.M. and 10 P.M., and it has returned to its original position between 5 A.M. and 10 A.M. Because the waves on the original diagrams are long and flat it is usually difficult to determine with any accuracy the exact time at which an excursion in any one direction has been completed. Sometimes the boom has remained at rest at one of its limits for five or six hours before the return journey has been commenced. The movement from 5 or 10 A.M. until 4 or 10 P.M. has nearly always been quicker than the return motion during the night.

The amplitude of motion does not seem ever to have exceeded 3″·00. In 1893 I described movements of from 2″·00 to 10″·00; but these which I now discuss are the result of observations with several instruments, although I cannot answer for any great degree of accuracy, I am inclined to consider the new determinations as being nearer the truth. The movements of E, which is underground, have usually been greater than those recorded by A in my house. In a few instances, however, the deflections of A have been the greater.

As an appendix to the table on p. 97 short abstracts from my journal are added :—

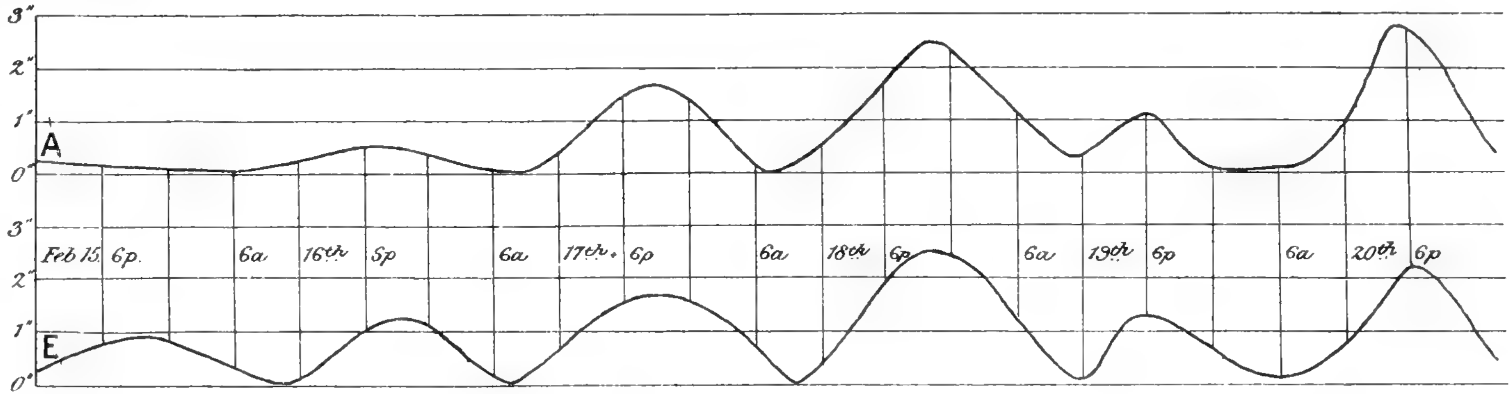
(i) *Extract from Journal of Records obtained in* 1894.

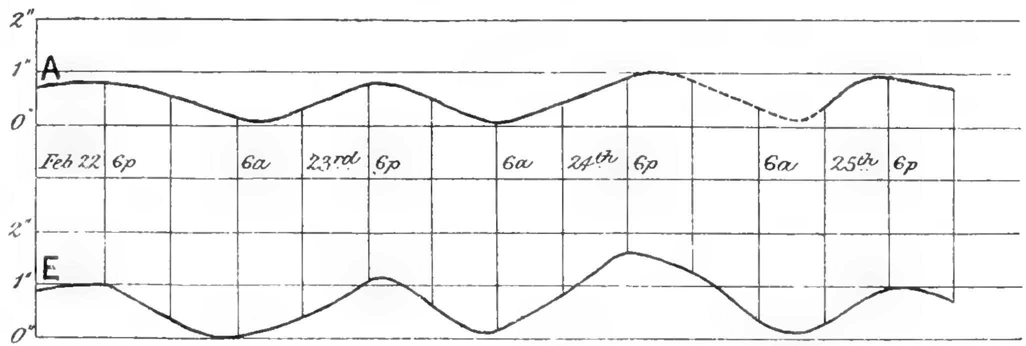
In the following extracts the sensitiveness of the instruments means the angular tilting required to produce a deflection of one millimetre of the points at the end of the booms. These degrees of sensitiveness for the instruments E, A, and F are given in fractions of seconds of arc immediately after the date.

January 24–27 (0″·18, 0″·23, 0″·43).—From the 24th to the 25th E showed a rapid S.E. lifting of 3″ when the light spot left the film. A small earthquake occurred at 10.48 A.M. on the 25th. From the 25th to the 27th there was a S.E. lifting of 1″·62. Daily waves of 1″·44 and 1″·26 are well marked. All instruments showed tremors, but they are most marked underground on E, where they reach 12 mm. On A and F the daily waves are hardly visible.

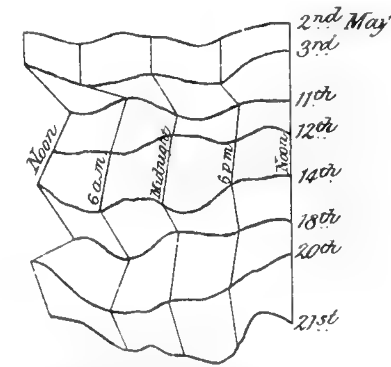
January 27–30 (0″·19, 0″·23, 0″·18).—E moved 5″·32, and the light spot left the film. It shows tremors reaching 14 mm. A and F agree in showing a N.E. lifting, but the daily wave is only seen on A when the tremors reach 10 mm. The tremors are most pronounced underground.

January 30–*February* 2 (0″·43, 0″·23, 0″·18).—E shows similar characters to A and F, that is, the trace is at first straight, and then two daily waves and three small earthquakes. For the first day A and F are straight, but for the other two days there are daily waves. F shows a





Diagrams showing daily movement of pendulums on the surface (A) and underground (E).



Tracings showing daily motion of water in a well.

Illustrating the Fourteenth Report of the Committee on the Earthquake and Volcanic Phenomena of Japan.

Date	E			A			F			Rainfall in mm.
	Time of Crest of Wave	Amplitude	Time of Sinus of Wave	Time of Crest of Wave	Amplitude	Time of Sinus of Wave	Time of Crest of Wave	Amplitude	Time of Sinus of Wave	
1894		″			″			″		
Jan. 24–25	3.30–9.30 P	2·70	—	s	—	—	s	—	—	—
„ 25–26	11.30 P–1.30 A	1·44	—	1.0 A	—	—	s	—	—	16
„ 26–27	11.0 P–12.0	1·26	9.0 A	s	—	—	s	—	—	—
„ 31– 1	6.0 P–8.0 P	0·86	9.0 A	6 P	0·69	7.0 A	9.0 P–10.0 P	0·36	4.0 A	—
Feb. 1– 2	7.0 P–9.0 P	0·60	5.0–9.0 A	5 P–6 P	0·92	6.0 A	8.0 P–9.0 P	0·36	—	—
„ 2– 3	6.0 P	0·80	7.0 A	—	—	—	—	—	—	—
„ 3– 4	6.0 P	0·80	7.0 A	—	—	—	—	—	—	—
„ 4– 5	1.0 P	0·80	7.0 A	—	—	—	—	—	—	—
„ 5– 6	—	—	6.0 A	8 P–9 P	—	—	s	—	—	—
„ 6– 7	5.0 P–10.0 P	1·29	8.0 A	5 P–6 P	1·61	9.0 A	s	—	—	—
„ 7– 8	5.0 P–10.0 P	0·85	6.0 A	5 P–6 P	1·15	8·30 A	s	0·46	—	—
„ 8– 9	—	0·86	7.0 A	—	—	—	—	—	—	27
„ 9–10	4.0 P–4.0 A	s	10.0 A	4 P	0·78	—	s	—	—	—
„ 10–11	7.0 P	0·86	3.0 A	3 P–5 P	0·78	—	s	—	—	—
„ 11–12	7.0 P	0·86	—	—	—	—	s	—	—	—
„ 12–13	10.0 P	0·86	6.0 A	—	—	—	Large and irregular			—
„ 12–14	3.0 A	0·86	7.30 A	—	—	—	s	—	—	—
„ 14–15	9.0 P	1·29	7.30 A	—	—	—	s	—	—	—
„ 15–16	12.0 PM	0·43	10.0 A	—	0·1	6.0 A	—	—	—	—
„ 16–17	10.0 P–12.0 P	1·29	8.0 A	6 P–8 P	0·5	9.0 A	—	—	—	—
„ 17–18	10.0 P–12.0 P	1·72	9.0 A	6 P	1·75	7.0 A	—	—	—	—
„ 18–19	9.0 P	2·58	10.0 A	10 P	2·50	11.0 A	s	—	—	—
„ 19–20	6.0 P	1·29	6.0 A	6 P	1·25	1 A–6 A	s	—	—	—
„ 20–21	6.0 P	2·15	6.0 A	7.0 P	2·25	2 A–6 A	—	s	—	1
„ 21–22	—	—	—	—	—	—	—	—	—	2
„ 22–23	6.0 P	1·72	6.0 A	4.0 P	0·75	7.0 A	—	s	—	—
„ 23–24	4.0 P–6.0 P	1·29	6 A–7 A	6.0 P	0·75	6.0 A	—	s	—	—
„ 24–25	6.0 P	1·72	6 A	5.30 P	0·75	—	—	s	—	—
„ 25–26	6.0 P–7.0 P	1·72	6 A	4.0 P	—	—	—	s	—	—
„ 26–27	10.0 A	2·58	6 A	—	s	—	—	s	-	—
Mar. 1– 2	11.0 P	3·01	9.0 A	—	0·5	—	—	—	—	—
„ 2– 3	6.0 P–1.0 A	2·15	5.0 A	—	0·5	—	—	—	—	2
„ 3– 4	6.0 P–12.0 P	0·86	2.0 A	—	—	—	—	—	—	2
„ 5– 6	7.0 P	1·29	10.0 A	—	s	—	—	s	—	—
„ 6– 7	8.0 P	2·15	10.0 A	—	s	—	—	s	—	—
„ 7– 8	9.0 P	1·72	9.0 A	—	s	—	—	s	—	—
„ 8– 9	—	s	—	—	s	—	—	—	—	12
„ 9–10	—	s	—	—	s	—	—	—	—	3
„ 10–11	—	s	—	—	—	—	—	—	—	12
„ 12–13	—	s	—	2.0 P	1·0	6 A	—	—	—	—
„ 13–14	—	s	—	Irregular			—	—	—	—
„ 15–16	Clock repairing			—	—	—	—	—	—	8
„ 16–17	„	„		8.0 P	2·5	12 A	—	—	—	35
„ 17–18	„	„		7.0 P	2·5	12 A	—	—	—	—
„ 23–24	„	„		6.0 P	1·60	10 A	—	—	—	—
„ 24–25	„	„		6.0 P	1·40	10 A	—	—	—	5
„ 26–27	„	„		1.0 P	1·60	10 A	—	—	—	4
„ 30–31	„	„		10.0 A	1·0	6 A	—	—	—	20

steady N.E. rising of 2″·70 until February 2, when at 7 P.M. there was an earthquake. Tremors are slight.

February 2–5 (0″·43, 0″·23, 0″·23).—E shows the usual daily tilting with small trêmors. After the earthquake of the 2nd F continued to rise until the 3rd, when at 8 P.M. the light left the film.

February 5–7 (0″·43, 0″·23, 0″·23).—The daily waves in E and A are pronounced, and when one is large the other is large also, and *vice versâ*. In F the waves are not so marked. Tremors are slight on A, but underground in E and F they reach 3 mm.

February 8–12 (0″·43, 0″·26, 0″·23).—E daily deflection (9–10) slight, but from 10–11 like A. On A the daily deflections are well marked, but on F they are very slight. F, however, falls from 84–67 (3″·91). Tremors are greater on the surface, reaching 6 mm., than they are underground.

February 12–15 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}39$).—E shows well-marked daily curves. A out of order, and therefore no record. F found to have changed its sensitiveness; therefore reset, so that $1°=0''{\cdot}23$. From 12–13 F wandered from 75·5 to 52 ($8''{\cdot}97$), and again from the 14–15 it crept from 72 to 62 ($2''{\cdot}30$). These movements, which so often occur with F, mean a change in sensibility.

Both instruments show tremors of 3 mm.

February 15–19 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).—On E and A the daily waves are seen as a succession of symmetrical waves, gradually increasing in height and in length. Close upon the crest of the last and largest of these waves an earthquake occurs. F only shows the last of these daily waves, the remainder of the trace being a straight line, indicating a slight N.E. sinking ($1''{\cdot}30$). Tremors on all three instruments are slight.

February 19–22 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}25$).—E and A show a continuation of the daily waves. Between the 21st and 22nd both instruments gave a straight line. F only shows the wave of 20–21, but it shows a N.E. sinking from 76 to 40 ($8''{\cdot}00$).

On the 20th, at 9.30, there was a strong shock. A shows two series of strong tremors, which are only faintly indicated by the underground instruments.

February 22–26 ($0''{\cdot}43$, $0''{\cdot}25$ $0''{\cdot}26$).—E and A show well-defined daily waves. F is nearly a straight line, but wandered about 30 mm., as if N.E. had sunk.

Tremors are seen from 6 A.M. until noon on the 23rd, and again from 6 P.M. on the 24th to 4 P.M. on the 25th: on A and F they reach about 5 mm.

The earthquake of the 24th is not shown.

February 26–*March* 1 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).

The daily curves on E are marked, but they are irregular. The shock of the 27th occurs just over the crown of the daily wave, which was at 10 P.M. The crest of this tilting, both in time and amplitude, was unusual.

On A and F the daily curves are slight; on A, like E, they are irregular.

Tremors of 2 or 3 mm. are shown on A and F on the 26th, 6 to 7 P.M.; 27th, 6 A. to 4 P.; and on the 28th, 6 A. to 1 P. The last are visible on E.

F wanders by a N.E. sinking through 10 mm. On March 1 the direction of motion commenced to change, that is, there was a N.E. lifting.

March 1–5 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).—On E the daily curves are large, but at unusual times.

A shows slight daily curves, but a N.E. lifting of 10 mm. F shows a N.E. lifting of 22 mm.

Tremors are seen on A on the 2nd, 2 A. to 11 A.; and this agrees with E, but not with F, which shows slight tremors, March 1, from 9.30 A. to midnight.

March 5–8 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}25$).—E shows a well-marked series of daily curves, and wanders 8 mm., as if the S.E. was rising. The daily curves on A are slight, but the trace is faint. F wanders 40 mm. as if the N.E. was rising.

On March 6 small tremors are recorded, but only on A.

March 8–12 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).—E shows slight daily curves on the 8th, 1 P. to 10 P. A sinks on N.E. side 4 mm., showing tremors of 6 mm. It then rises to the 10th, 8.30 P. 12 mm. At 8.40 an earthquake.

F rises on N.E. side 40 mm.

Tremors on E and F are slight.

March 12–15. ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).

The daily curve is barely visible on E, which shows small tremors. A shows curves, but they are irregular, and the N.E. sinks 15 mm. F rises 23 mm., that is, the direction of motion is contrary to A. Both A and F show small tremors.

March 15–19 ($0''{\cdot}43$, $0''{\cdot}25$, $0''{\cdot}26$).—E clock stopped, and therefore no records until end of month. From the 15th to 16th A was steady, but from this date onwards it gave large daily curves.

On the 15th, and at 3 A.M. on the 18th, there were earthquakes. During the three days A rose 9 mm. F does not show daily curves, but it rose 39 mm.

The conclusions I arrive at respecting this section of the report is, that instruments on the surface and underground show diurnal movements, which closely agree in the times at which they occur. These movements are most pronounced underground by pendulum E, the excursions of which have in nearly all instances been greater than those shown by pendulum A in my house. The crest of a wave which corresponds to a N.E. lifting on A and a S.E. lifting on E has usually been reached between 4 P.M. and 10 P.M., the movement in the opposite direction being completed between 5 A.M. and 10 A.M. It does not seem that air temperature has had any measurable effect in the production of these movements, because they have been most marked beneath the surface, where the change in temperature during twenty-four hours has practically been zero. The opportunities for observing whether they hold any relationship with rainfall have been few. It is possible that the rainfall of March 16 and 17 may have been connected with the large motions of A between March 16 and 18, but the largest motions of E on March 1 and 2 occurred during a dry period. After the rainfall of January 25 and 26, and again after that of February 8 and 9, it may be noticed that the time at which E completed its N.W. excursion was delayed, while after that of March 16 and 17 pendulum A was delayed in its N.E. movement, and these are the only occasions on which rain fell in any quantity.

(*j*) *The Wandering of the Pendulums.*

The following table shows the daily change which has taken place in the position of the pointer of pendulum A, and for a few days that which has taken place with pendulums F and E. The numbers indicate so many millimetres of motion. The sign + prefixed indicates that the scale readings were increasing, while the sign – indicates that they were becoming smaller. When the signs for A and F are similar, then these two pendulums were moving in the same direction. The difference between the readings of an instrument when a new film was put on and when it was taken off gives the distance through which a boom has been displaced during periods of three or four days: this quantity is also expressed in seconds of arc. The fifth column gives the rainfall in millimetres, and the sixth the number of hours of sunshine, but only between February 25 and April 30. These latter records were taken for me by my colleague, Prof. W. K. Burton.

Date	A	F	E	Rainfall in mm.	Hours of sunshine	Earthquakes recorded by seismographs
Jan. 24–25	+1	−1	−2			1
„ 25–26	−1	+4	−6	16		
„ 26–27	−1	+1	+15			
{	−1	+4	+7			
	−0″·23	+1″·29	+1·26			
„ 27–28	+2	+12	+26			
„ 28–29	+3					
„ 29–30	+3	+5				
{	+8	+13	−3			
	+1″·84	+2″·34	−0″·57			
„ 30–31	−3	+1	+3			
„ 31–1 (Feb.)	+2	+6				
Feb. 1–2	−5	+4				
{	−7	+11	+2			1
	−0″·46	+2″·70	+0″·86			
„ 2–3	−4					1
„ 3–4	+3					
„ 4–5	0					
{	−1	−8	0			
	−0″·23	−1″·78	0			
„ 5–6	+12					
„ 6–7	+1					
„ 7–8	+1	−8				
{	+14	−8	+2			
	+3″·22	−1″·74	+0″·86			
„ 8–9	−6	−6		27		
„ 9–10	−1					
„ 10–11	0					
„ 11–12	−1			1		
{	−8	−17	+2			
	−2″·08	−3″·91	+0″·86			
„ 12–13	−2	−23	−3			
„ 13–14	+4	+22	0			
„ 14–15	0	−10	+5			
{	+2	−11	+2			
	+0″·5	−5″·07	+0″·86			
„ 15–16	−4					
„ 16–17	+8					1
„ 17–18	+5					
„ 18–19	−8					1

Date	A	F	E	Rainfall in mm.	Hours of sunshine	Earthquakes recorded by seismographs
{	+1 +0″·25	−5 −1″·30	+3 +1″·29			
Feb. 19–20	+10					1
„ 20–21	−12			1		
„ 21–22	−1			2		
{	−3 −0″·75	−24 −6″·0	−3 −1″·29			
„ 22–23		+3	0			
„ 23–24	−2					
„ 24–25	+3				8	2
„ 25–26	+1				5	
{	+5 +1″·25	+3 0″·78	0 0			
„ 26–27	−2				7	1
„ 27–28	+2				9	1
„ 28–1 (Mar.)		−10				
{	+1 +0″·25	−4 −1″·04	0 0			
March 1–2	+4	+4	+2			
„ 2–3	+4			2	2	
„ 3–4	+1	+30	−3	2		1
„ 4–5						1
{	+9 +2″·25	+32 +8″·32	−1 −0″·43			
„ 5–6	+1	+27	+6	6		1
„ 6–7	+2	+15				
„ 7–8	−4	+15	+4			
{	−1 −0″·25	+15 +3″·75	+8 +3″·44			
„ 8–9	+1			12		
„ 9–10	+6			3		
„ 10–11	0			12		1
„ 11–12	−6			2	9	
{	+1 +0″·25	+34 +8″·84	−1 −0″·43			
„ 12–13	−6				9	1
„ 13–14	−6				4	2
„ 14–15	−3			6	5	1
{	−15 −3″·25	+23 +5″·98	−2 −0″·86			

Date	A	F	E	Rainfall in mm.	Hours of sunshine	Earthquakes recorded by seismographs
March 15–16	+8			8	6	1
„ 16–17	+6			35	6	
„ 17–18	−3				9	
„ 18–19	−2				3	
	+9	+39	+8			
	+2″·25	+10″·14	+3″·44			
„ 19–20	−4					
„ 20–21	−4				4	1
„ 21–22	−2				9	1
	−10					
	−2″·50					
„ 22–23	−7				9	9
„ 23–24	−6					
„ 24–25	+18					
	+5	+4				
	+1″·25	+1″·04				
„ 25–26	+9			5		2
„ 26–27	−4	−3		4	2	
„ 27–28	0			20		
„ 28–29	−6	−7			8	
	−1	−10				
	0″·20	−2″·60				
„ 29–30	−1			1	6	1
„ 30–31	+1				5	
„ 31–1 (Apr.)	+1				8	1
	+1	−18				
	+0″·20	−4″·68				
April 1–2	−6				10	1
„ 2–3	+2				8	
„ 3–4	+6				8	
	+2	−4				
	0″·40	−1″·04				
„ 4–5	0				1	1
„ 5–6	+5			7		
„ 6–7	0			6		
„ 7–8	−1			5		1
	+4	+2				
	+0″·80	+0″·52				

Date	A	F	E	Rainfall in mm.	Hours of sunshine	Earthquakes recorded by seismographs
April 8–9	+1			8		
„ 9–10	−2			14		
„ 10–11	+1					
„ 11–12	−5				4	
	−5 −1″·00	+2 +0″·52	+8 +4″·08			
„ 12–13	+6					1
„ 13–14	+30			23	10	2
„ 14–15	−6			8	8	1
„ 15–16	−6				8	
	+24 4″·80	+5 +1″·30	−8 −4″·08			
„ 22–23	−2				8	
„ 23–24	+2			8	9	
„ 24–25	−1			23		1
	−1 −·22	+2 +2″·06	−1 −1″·5			
„ 25–26	+4					
„ 26–27	−2			19	5	
„ 27–28	+10			56		1
„ 28–29	−2					
	+10 +2″·30	0 0	0 0			
„ 29–30	+6	+3	−11			
	−10					
„ 30–1 (May)	0					
May 1–2	0	−1	−10	3		
	−4 −0″·92	+1 +0″·3	−21 +2″·32			
„ 2–6	+1 +0″·23	−8 −0″·96		26		
„ 6–9	+1 +0″·23	−1 −0″·12	−11 −1″·32	17		
„ 9–13	−4 −0″·92	+19 +2″·0	−16 −1″·60			
„ 13–16	+7 +1″·51	0 0	−4 +1″·72			

An examination of the above table leads to several important results. In twenty-four cases the motion underground has been greater than that on the surface, while in six cases it has been less than that on the surface. These instances are taken from the three or four day periods. If the analysis was made for daily periods, the difference between the amount of motion recorded underground and that recorded on the surface would be yet more marked. Whenever the movements of the surface instrument A have been great, exceeding 1″ in seven instances, its direction of motion has corresponded with the direction of movement of the instrument which is placed in a parallel direction F. In two cases the directions of movement between A and F have been opposite to each other. When, however, the movements of A have been small or less than 1″ the cases of agreement and of disagreement in direction of motion are practically equal, there being 6 of one and 11 of the other. For January, February, and March rainfall seems to have been followed by considerable disturbances underground, the movements during dry periods being comparatively small. The instrument on the surface has, however, shown several marked exceptions to the latter rule, its pointer having moved from 8 to 12 mm. (2″ to 3″) at least five times when the displacement could not be attributed to the saturation of the soil.

During April and May, although a considerable amount of rain fell, the movements of the underground instruments were small, but it must be remembered that during these months percolation was in all probability very small as compared with that of January, February, and March. Instrument A, on the contrary, showed on several occasions very large movements between April 13 and 14, moving as much as 30 mm. or 6″, and from what has gone before it is not necessary to assume that these disturbances were directly connected with rainfall.

Up to the date of writing this report I have not been able to obtain from the Meteorological Department factors which enable me to make any accurate estimate of the ratio of percolation to evaporation, but it may be taken, as a general rule, that percolation and the fluctuations in height of subterranean water are greater during the winter months than they are during the summer, and if the instruments partly owe their movements to movements of underground water, these movements ought to be most pronounced in winter, and this seems to have been the case. Since the commencement of May, up to June 6, E and F have wandered but little, the diagrams being fine straight lines like fig. 1, Plate II., and without tremors. It must also be observed that it has been the instruments in the underground chambers within 12 feet of water level which have moved the most.

To throw additional light upon the part that subterranean water may have played in influencing the motion of the pendulums the following experiments were made :—

1. The movements of water in an unused well were recorded.

2. A rough measurement of the rate at which moisture was evaporated from ground near to one of the instruments was made.

3. A well near to one of the instruments was twice emptied of its water.

(*k*) *Movements of Water in a Well.*

From April 18 until June 8, I established a tide gauge in an unused well 80 yards to the east of the underground chamber. It consisted of a large wooden float carrying a bamboo mast 30 feet in length, the top of which projected through a hole in a lid which covered the top of the well. As the mast rose and fell a pencil in contact with a sheet of paper on a drum recorded the motion. The diagrams obtained indicate the following facts. Very shortly after heavy rain the well commences to rise, and the rising continues for three or four days after the rain has ceased. The upward motion, which at times has been as much as 7 or 8 inches in 24 hours, eventually becomes slower for about two days, after which the water falls slowly. A more important observation, however, is that during any 24 hours there are fluctuations in the rate of rising or falling which when the well is nearly steady are distinct, but when the coming up or going down of the water is rapid they are barely visible. A number of these daily fluctuations are shown on Plate IV. About midnight and for some hours afterwards the water is at its highest, and it is again high during the middle of the day. It is lowest in the evening and the early morning, which is the time when the greatest quantity of water is being drawn from wells throughout the city. The nearest well from which water is drawn to the one in which the gauge is established is on the east side, about 60 yards distant.

In the following table the dates refer to the interval between noon of one day to noon of the succeeding day. The figures in the columns indicate the hours at which the well *commenced* to sink and then to rise in the afternoon and evening, and when it again commenced to sink and to rise in the morning. The time midway between the rising in the evening and the sinking in the morning may be taken as the crest of the night wave, the crest of the midday wave being halfway between the A.M. rising and the P.M. sinking of the next day. The omission of dates or hours indicates that the inflections on the diagram were indistinct or absent. The letters R, F, or S in the sixth column indicate whether the well was rising, falling, or steady.

The time at which the well commences to rise in the evening is fairly constant, about 8 P.M. This precludes the idea that the diurnal motion may be dependent upon the tides in the neighbouring bay, which is some two miles distant. The most irregular figures are those indicating the time at which the well commences to sink in the morning, which as summer approaches, when the city rises at an earlier hour, also tends to become earlier, and therefore assist in confirming the suggestion, that the rising and falling of the water are due to the facts that larger quantities of water are being used in the morning and evening than are being used during the middle of the day and the middle of the night.

The amount of these fluctuations has seldom exceeded 5 mm., and the day and night waves have about the same amplitudes. Professor Franklin H. King found that a heavily loaded train moving slowly past a well at a distance of 140 feet caused the water in the well to slightly rise, from which it might be inferred that the rising and falling of water in a well might be accompanied by a rising and sinking of the surrounding surface. If this were the case then during a day and night the horizontal pendulums in Tokio ought to show a double curve. In some few instances there is a tendency to show such a double motion, as, for example, in fig. 5, Plate II. But because one of the curves is faint and because it is of rare occurrence, the 12-hour movement in the well is by no means sufficient to explain the daily wave indicated by the pendulums. It must, however, be remarked that the period of well observations coincides with a period when daily curves were not well marked, and what happened in the well when they were distinctly marked I have at present no means of ascertaining.

Date	P.M.		A.M.		General behaviour of well
	Sinking	Rising	Sinking	Rising	
April 18–19	—	6	—	—	R
„ 20–21	—	—	5	—	„
„ 21–22	—	8	9	—	„
„ 22–23	6	8	—	—	„
„ 23–24	—	—	6	—	„
„ 24–25	—	10	—	—	„
„ 30–1 (March)	6	8	3	6	„
March 2–3	2	8	4	7	„
„ 3–4	—	8	1	—	„
„ 6–7	5	8	6	—	„
„ 7–8	6	9	3	9	„
„ 9–10	—	8½	4	—	„
„ 10–11	3	9	—	—	„
„ 11–12	3	8½	6	11½	„
„ 12–13	3	7	3	7	„
„ 14–15	6	10	5	7	S
„ 15–16	—	—	5	—	„
„ 18–19	3	7	1	6	F
„ 19–20	2	6	—	—	„
„ 20–21	5	10	2	6	„
„ 21–22	4	9	4	8	„
„ 25–26	4	8	—	—	„
„ 26–27	4	9	1	6	„
„ 27–28	3	7	2	6	„
„ 28–29	5	8	1	6	„
„ 29–30	4	9	3	6	„
„ 30–31	1	7	3	6	„
June 1–2	3	9	—	—	„
„ 3–4	—	7	1	5	S
„ 4–5	2	7	1	5	F
„ 5–6	—	9	2	8	S
„ 6–7	6	9	6	7	„
„ 7–8	5	9	5	8	„

(*l*) *An Experiment on Evaporation.*

Because it was found that a load of about 1,000 lb., made up of men and boys standing outside my observatory wall at a distance of 15 feet from pendulum A, would deflect it 2 mm., the following experiment was made.

In my garden a strong beam was rested on knife edges on the top of a stake driven into the ground. On one end of this a box 1 foot 6 inches square, and 6 inches deep, was hung, so that it could swing freely in a hole cut in the ground. The box was filled with earth which came from the hole, and was covered with turf like the surrounding lawn. This load was balanced by weights suspended at the other end of the beam attached to which there was a pointer moving over a scale. During three fine days it was found that the box lost weight at the rate of about ½ lb. per day per square foot of surface, and as the surface of the material in the box was similar to that of the surrounding ground with which it was level, it was concluded that similar ground in the neighbourhood lost weight at about the same rate.

During a night the gain by precipitation of dew was sometimes as much as 1·2 oz. per square foot. No doubt many accurate observations have been made on the variation in the rate of evaporation and condensation of moisture from and upon various natural surfaces, but I have not been able to consult them.

In open ground 30 per cent. of the rainfall may percolate, but in a forest as much as 80 per cent. may find its way downwards, the difference being due to evaporation ; but as evaporation may cease or even be represented by condensation during the night, it would seem that the volume of water in surface wells especially on hot days following rainy weather might have a daily fluctuation. Such a fluctuation would, however, only account for the rising of water during the night and for an additional rise about midday.

Another point to be noted is the fact that the alternations of evaporation and condensation mean that neighbouring areas, some of which are open and others covered with forest every 12 hours, are *unequally* relieved of considerable loads. For example, from an area of about 140 feet square in front of my house, which faces south, every day during fine weather about 5 tons of moisture are removed. From the back of the house, which is sheltered from the sun, and where the ground is always damp, comparatively but little is evaporated. The underground chamber is sheltered by a grove of trees on its south and west sides, and on the east side it is open, and pendulum E behaves as if a load were removed from the east side during the morning and afternoon, and that side of the ground had consequently risen. Pendulum A in my house, where there is an evaporation area on the east, south, and partly on the west side, usually behaves like E, to which, however, it is at right angles.

By comparing the table of daily waves with the rainy days when there was no sunshine, when it may be assumed that evaporation was small, as, for example, between March 8 and 11, it will be observed that the daily curves for A and E were not measurable. On sunny days, even if it rained, the curves were pronounced, but they were also large on other days, when, however, evaporation may possibly have been great.

To settle this question future diagrams must be compared with the records obtained from a hygrometer exposed to the open or by two pendulums in parallel positions, but on the opposite sides of a piece of forest land. Two pendulums thus placed ought at the same time to move in opposite directions, that is, during the day each boom ought to move towards the forest.

An observation entirely opposed to what is here suggested is that made by Professor Kortazzi at Nicolaiew, who placed a hydrograph in the cellar where a horizontal pendulum was established, and found that the diagrams given by the two instruments were very similar. This he attributed to the stone column carrying the pendulum behaving like a sponge and absorbing moisture. When the openings to the cellar were closed and the pillar covered with a waterproof material the *effect of moisture almost entirely disappeared.*

(*m*) *Effects produced by emptying a Well.*

To determine what effect a slight disturbance of subterranean water would produce on a horizontal pendulum, on May 21 I employed men to rapidly empty a well which is 104 feet distant in an E.N.E. direction from pendulum A. The well is 42 feet 7 inches deep, 2 feet 7inches in diameter, and on this particular day it contained 13 feet 1 inch, or about 2 tons of water.

For several days the pointer of the pendulum had been fairly steady, pointing at division 70 on the scale of millimetres. What happened when the well was emptied is given in the table below.

The photographic trace with interruptions in it when the light was removed is shown in fig. 7, Plate II. The movement of the pointer from 70 to 79 indicates a tilt of 1″·36 and the direction of motion was as if a load had been taken away on the well side, and the ground on that side had therefore risen. This may be explained by the fact that as the water came to the surface it was run into a gutter to flow away quickly down a hill. The pendulum remained between 77 and 82 until May 27, when the experiment was repeated. It started at 80, and in 6 hours and 40 minutes it reached 86, and here it has remained with a tendency to get higher but not to return.

Day	Time	Position of pendulum	Distance to water ft.	Distance to water in.	Remarks
21st	8.30 A.M.	70	36	6	Taking out water for house
	8.40 "	72			
	8.50 "				Commence to empty well
	9.5 "	72			
	9.30 "	73			
	9.45 "	73	48	11	Well empty excepting 8 inches. Water bubbling in
	11.00 "	75	40	7	Water rising
	12.00 "	76			
	12.30 P.M.		37	8	" "
	4.00 "	79			Maximum deflection reached
	5.25 "	79	36	0	Water higher than at the commencement
	7.10	77			
22nd	7.30 A.M.	77	35	10	" " "

Not only was tilting produced by these operations, but as seen in the photograph tremors were induced.

It might have been anticipated that by emptying the well and the subsequent inflow of water to refill the same—if in consequence of this operation a superficial movement took place—this would have assumed the form of a quaquaversal dip towards the well. What happened was exactly the reverse, from which it may be inferred that the motion of the pendulum was due to the removal of a weight rather than to the movement of the subterranean water.

(n) *Earthquakes.*

In the last column of the table showing the wandering of pendulums, the number of earthquakes which occurred on various days is given. These are the earthquakes which were recorded by seismographs in Tokio, and it is only one or two of these like the disturbances of March 22, when earth waves were produced, that are recorded by the pendulums. As already stated when speaking of the Kamakura records, although it is probable that most of these shocks were of local origin, this fact cannot be ascertained until the records accumulated at the Meteorological Department have been analysed. Two things, however, are very remarkable, the first being that at about the time of nearly all the shocks, pendulum A has shown abnormally large movements, and secondly there are only three occasions when the movements of A have been moderately large that earthquakes have not occurred. The tremor storms which were numerous in the early part of the year have no doubt obliterated many of the unfelt earthquakes to which the pendulums were sensitive. Notwithstanding this, there are a considerable number of disturbances on the traces, the record of which must be left for a future report. The most remarkable of these was recorded by pendulum F, which at the time was steady and producing a clear sharp straight line (see fig. 3). This was on June 3, when at 4.36 P.M. the pendulum commenced to move from side to side, and, with the exception of two or three intervals of about five minutes, it continued to move until 10 P.M. Although 14 points of maximum may be counted, the photograph represents what is practically a continuous earthquake of 5 hours 24 minutes' duration. The picture is that of a series of small flat cones, each inverted, with their axes in one straight line. No displacement of the pendulum took place, and after the

FIG. 3.

About half actual size.
The gap at or near noon represents an interval of one hour.

disturbance it continued to draw the same thin line. I do not know where this or the other unfelt earthquakes originated. The rate at which the decided movements are propagated is from 2·5 to 4 kilometres per second, and there are reasons for believing that many of them, like that of March 22, originated beneath the bed of the ocean.

(*o*) *Tremors.*

In the extracts from the Journal (pp. 96 to 99) it will be seen that tremors or earth pulsations have often been recorded, and that sometimes these were greater underground than on the surface. During the last two months they have been greater on the surface. Previous analyses have shown that they nearly always accompany a steep barometric gradient. They are sometimes marked when the daily curve is barely visible, but small tremors at least usually accompany these waves, and they are more pronounced during the night and early morning, when the rate at which a pendulum is being displaced is relatively slow. The fact that small tremors were produced at the time the well was emptied is a fact not to be overlooked when considering their origin.

I regret to say that a more careful examination of the tremor records must be left for a future report.

(*p*) *Observations at Yokohama and Kanagawa.*

As already stated, the instruments at Kanagawa (I) and (G and H) at Yokohama are underground, and stand on short brick columns rising from soft tuff rock. The softness of this rock may be judged of from the fact that when a person stands near one of the columns, the boom of the pendulum is deflected from 5 to 17 mm., from which it appears that, as a foundation to resist loading effects, the tuff rock is no better than a slab of concrete on the alluvium in Tokio. Owing to the collapse of the roof of the Yokohama cave, which caused a delay of two weeks, and owing to the fact that the clocks have been continually stopping, and good clocks cannot be found in Tokio or Yokohama, the records from this place are extremely few. Those which have been obtained, extending over two or three days, show straight lines like fig. 1, Plate II. There are neither daily curves nor tremors.

From Kanagawa, although the cave is very wet and the conditions for observing very unfavourable, for about two months everything has worked satisfactorily. Like the Kamakura records they do not show tremors or daily waves, but they do show unfelt earthquakes and wandering. For example, on May 5 the boom moved as if by a N.E. tilting as much as 14″. This it reached on May 7. From this date it slowly returned to its starting point, which it reached on May 12. Small shocks occurred on the 2nd, 4th, and 6th.

(q) *Conclusions.*

Inasmuch as the analysis of materials already accumulated is not yet completed, and as certain experiments require to be repeated or amplified, it is premature to formulate definite conclusions. All that can therefore be done is to outline the form which conclusions may possibly assume.

Although I understand that Italian observers have found that tremors are as marked underground, even on the rock, as they are on the surface in Japan, this seems to be only true for the alluvium. Underground on the rock at three stations, with such instruments as I have employed, there has *not been even an indication of tremors. Neither have daily waves been observed.* All the pendulums, whether on the rock or on the alluvium, from time to time leave their normal position, moving for two or three days in one direction and then slowly returning. These movements, which have been called wanderings, sometimes indicate a tilting of as much as 14″. Because these movements have often been accompanied by local earthquakes, it seems possible that they may actually represent rock bending, the earthquakes announcing the fact that resistances to the process are being overcome.

Some of the wanderings noted on the alluvium may possibly be attributed to disturbances in the subterranean circulation of water after rainfall.

Although the daily movement of the pendulums has been most marked by those which are nearest to water level, because they only show a single wave during the day, while the water in a neighbouring well rises and falls twice during the 24 hours, the daily wave cannot altogether be attributed to the movement of subterranean water. Because certain diagrams have shown a superimposed wave, it is possible that the character of the daily wave may now and then be influenced by subterranean water. Because a wave may be produced by relieving an area in the vicinity of a pendulum of a load, as, for example, by taking 2 tons of water out of a well which is 104 feet distant from pendulum A, and pouring the water away down a slope, it seems likely that the daily wave is produced by an action of this description. The action suggested is that which takes place every day when the sun shines or the wind blows across ground which is open and that which is covered, for example, by forests or buildings. By evaporation one area is rapidly relieved of a load, while the adjacent area loses but little. For example, experiment shows that on fine days an open grass-covered area 140 feet square in front of my house, which is 120 feet long and runs E. and W., loses in 12 hours about 5 tons of moisture. At the back of the house, where the ground is sheltered from the sun, evaporation is small. As confirming this view it is observed that pendulum A is steady on dull wet days, but on warm days the daily curves are well defined. Farther, although A and E move at the same time, they move in opposite directions, but each usually moves towards the side from which the greatest load is being removed by evaporation.

III. The Tokio Earthquake of June 20, 1894.

On June 20, at a few minutes past two in the afternoon, Tokio, Yokohama, and the surrounding districts were shaken by an earthquake which was more violent than any which has been recorded since 1855. On June 25 it was reported that in Tokio alone 33,940 buildings had suffered damage, some being entirely ruined, 140 persons had been wounded, and that 26 had been killed. In Yokohama, where many chimneys fell and houses were unroofed, 6 people were killed. When statistics are completed and it is known what has happened in other places these numbers will be increased. Small fissures were formed in the ground at Tokio in 96 places, many walls were shattered, while stone lanterns and tombstones were overthrown, twisted, or deranged.

The following facts are taken or deduced from the records obtained at the Central Observatory and the University Laboratory, both of which are in Tokio, at a distance of about $1\frac{1}{2}$ mile from each other. To these are added observations from the Hitotsubashi Observatory, which is situated on soft ground lying between the Central Observatory and the University, at which places the ground is comparatively hard.

—	Central Observatory	University Laboratory	Hitotsubashi Observatory
Time	2 h. 4 m. 10 s. P.M.	2 h. 2 m. 30 s. P.M.	
Duration	4 h. 4 m. 48 s.	4 mins. 30 secs.	5 mins.
Direction	N.E–S.W.	N.E.–S.W.	
Maximum horizontal motion	76 mm. or 59 mm.	80 mm.	130 mm.
Period of " "	1·3 sec.	2 secs.	1·5 sec.
Maximum vertical motion .	18 mm.	10 mm.	45 mm.
Period of " " .	1·0 sec.		

At the University for the first 10 seconds the horizontal motion was slight, when it suddenly became severe, reaching 80 millimetres. The severe motion continued for about a minute, during which time there were more than 10 pronounced movements. As the range of motion was outside the limits of seismographs with multiplying indices these were deranged or broken, and complete diagrams were only obtained at the University and Hitotsubashi, where there are seismographs without such indices, the recording surfaces for which are only set in motion at the time of violent disturbances. Until the diagrams have been carefully analysed I am inclined to think that the recorded horizontal motions may represent the angles through which the seismographs have been tilted, rather than the range through which a given point suffered horizontal displacement.

Assuming for the present that these quantities are what they are represented as being, then at the University and at Hitotsubashi the maximum accelerations were respectively 400 and 1,000 millimetres *per sec. per sec.* In the Nagoya-Gifu earthquake of 1891, when nearly 10,000 lives were lost, the maximum accelerations, calculated on more certain data, varied between 3,000 and 8,000 millimetres *per sec. per sec.* At the University there is a seismometer, consisting of a number of iron shot, arranged on a ledge round the top of a strong post, beneath which there is a bed of sand. These shot were not projected, but all of them, excepting one on the N.E. side, simply fell. The duration of the disturbance is of course that given by seismographs. Horizontal pendulums may have been tilted backwards and forwards for one or two hours. For some time after the shock it was observed that the Sunida River, which runs through Tokio, rose and fell as if its bed continued to be agitated. The direction of motion, as with nearly all earthquakes, was varied, and the direction given is that which was most pronounced.

The times at which the commencement of the disturbance was recorded at places some distance from Tokio are as follows :—

District	Time. P.M. H.	M.	S.	Intensity
Yokosuka	2	4	20	Strong
Numazu	2	3	25	"
Utsunomiya	2	4	16	"
Mayebashi	2	5	0	" clocks stopped
Kofu	2	3	0	" " "
Choshi	2	4	0	Weak
Nagoya	2	4	44	"
Gifu	2	4	28	"
Osaka	2	4	0	" " "
Hikone	2	1	27	"
Fukushima	2	4	27	"
Aomori	2	6	0	Feeble
Sakaye	2	7	0	"

From these times and the distribution of destruction it may be assumed that Tokio was well within the epicentral area.

A remarkable feature distinguishing this earthquake from most others is that during the next three days instead of a long series of after shocks only three disturbances were recorded. The primary shock does not appear to have been accompanied by any sound, while one of the secondary shocks, at 4.25 P.M., on the 20th was preceded by a roaring sound.

At many places telegraph and telephone wires were broken. Underground the pipes of the Yokohama Waterworks were caused to leak, drains were deranged, and there was a falling in of material in a railway tunnel. A curious fact communicated to me by my colleague Professor W. K. Burton is that in his house, where he was barely able to keep his feet while the shaking was going on, several decanters were not upset, but their stoppers were shot out. This is similar to what has occurred on more than one occasion with the lamp glasses at the Kannonsaki lighthouse in Tokio Bay.

IV. Miscellaneous.

In addition to the foregoing work two numbers of the 'Seismological Journal' have been issued and the manuscript of a catalogue of Japanese earthquakes between 1885 and 1892 has been completed. This catalogue gives the date, the time, the area shaken, and the position of the origin for 8,337 shocks. Appended to each shock are a series of numbers, and a line traced through these, as shown on a key map, is an outline of the land area which was disturbed. The object of this catalogue, which is different from previous publications of the same description, was stated in the last report.

Investigation of the Earthquake and Volcanic Phenomena of Japan.—Fifteenth Report of the Committee, consisting of the Right Hon. Lord KELVIN, Professor W. G. ADAMS, Mr. J. T. BOTTOMLEY, Professor A.H. GREEN, Professor C. G. KNOTT, *and* Professor JOHN MILNE (*Secretary*). (*Drawn up by the Secretary.*)

CONTENTS.

I. THE GRAY-MILNE SEISMOGRAPH.

The first of the above seismographs, constructed in 1883, partly at the expense of the British Association, still continues to be used as the standard instrument at the Central Observatory in Tokio.

I am indebted to Mr. K. Kobayashi, the Director of the Observatory for the following table of its records :—

Catalogue of Earthquakes recorded at the Central Meteorological Observatory in Tokio between May 1893 *and February* 1894.

No.	Month	Day	Time	Duration	Direction	Maximum Period and Amplitude of Horizontal Motion		Maximum Period and Amplitude of Vertical Motion		Nature of Shock
						secs.	mm.	secs.	mm.	
1894.										
			H. M. S.	M. S.						
1,421	V.	22	11 51 48 P.M.	0 30	E.-W.	slight		slight		slow, weak
1,422	"	28	8 13 02 A.M.	—	—	—	—	—	—	slight
1,423	"	29	6 45 56 A.M.	—	—	—	—	—	—	"
1,424	VI.	5	0 28 05 P.M.	—	—	—	—	—	—	"
1,425	"	14	4 59 52 P.M.	—	—	—	—	—	—	"
1,426	"	20	5 16 52 A.M.	1 4	—	0·3	0·35	—	—	slow
1,427	"	"	2 4 10 P.M.	4 48	S.W.	1·3	76	1·0	18	quick, strong
1,428	"	"	4 22 44 P.M.	1 45	W.N.W.	1·2	0·6	—	—	slow, weak
1,429	"	"	9 34 51 P.M.	0 43	W.N.W.	0·7	0·6	slight		"
1,430	"	25	5 15 36 P.M.	1 45	W.S.W.	0·8	4·8	6·4	0·7	quick, weak
1,431	"	27	4 23 59 A.M.	—	—	—	—	—	—	slight
1,432	"	30	10 56 28 P.M.	—	—	—	—	—	—	"
1,433	VII.	9	9 41 19 P.M.	—	—	—	—	—	—	"
1,434	"	10	4 33 0 A.M.	0 45	E.-W.	0·5	0·6	—	—	slow
1,435	"	"	8 13 28 A.M.	1 34	E.-W.	0·6	0·6	—	—	"
1,436	"	12	0 54 28 A.M.	—	—	—	—	—	—	slight
1,437	"	17	11 1 21 P.M.	3 27	N.W.	0·7	1·7	0·5	0·6	quick, weak
1,438	"	25	10 24 2 A.M.	0 56	N.W.	0·6	0·8	0·5	0·2	slow, weak
1,439	VIII.	1	8 44 35 A.M.	—	E.-W.	slight		—	—	weak
1,440	"	"	4 0 13 P.M.	—	—	—	—	—	—	slight
1,441	"	29	7 55 18 P.M.	6 1	N.N.E.	1·8	1·8	—	—	slow, weak
1,442	IX.	12	9 0 15 P.M.	0 57	N.W.	0·6	0·7	slight		"
1,443	"	13	3 40 3 P.M.	—	—	—	—	—	—	slight
1,444	"	17	8 53 56 P.M.	1 25	S.S.W.	1·2	0·5	—	—	slow, weak
1,445	"	21	8 2 36 A.M.	—	—	—	—	—	—	slight
1,446	"	"	7 58 16 A.M.	—	—	—	—	—	—	"
1,447	"	"	10 25 41 P.M.	—	—	—	—	—	—	"
1,448	"	24	4 32 28 P.M.	—	—	—	—	—	—	"
1,449	"	29	7 24 43 A.M.	—	—	—	—	—	—	"
1,450	X.	7	8 30 3 P.M.	8 0	N.W.	2·3	43·7	1·7	2·4	quick, strong
1,451	"	8	9 48 28 A.M.	—	—	—	—	..	—	slight
1,452	"	22	5 36 31 P.M.	—	E.-W.	—	—	—	—	slow, quick
1,453	XI.	11	8 54 4 P.M.	—	—	—	—	—	—	slight
1,454	"	15	9 42 39 P.M.	—	—	—	—	—	—	"
1,455	"	18	1 8 13 P.M.	1 38	N.-S.	1·3	0·2	—	—	slow, weak
1,456	"	21	10 42 14 P.M.	—	—	—	—	—	—	slight
1,457	"	22	8 13 53 A.M.	—	—	—	—	—	—	"
1,458	"	28	1 5 22 A.M.	3 56	E.-W.	3·0	1·5	—	—	slow, weak
1,459	"	"	6 44 51 A.M.	—	—	—	—	—	—	slight
1,460	"	30	8 30 57 P.M.	1 27	W.N.W.	0·6	5·0	0·2	1·7	quick, strong
1,461	XII.	1	6 36 59 P.M.	0 49	N.W.	0·8	0·7	—	—	quick, weak
1,462	"	16	1 7 0 P.M.	—	—	—	—	—	—	slight
1,463	"	23	3 5 1 P.M.	—	—	—	—	—	—	"
1,464	"	28	1 4 30 A.M.	—	—	—	—	—	—	"
1,465	"	31	10 7 42 A.M.	3 5	W.N.W.	1·6	1·8	—	—	slow, weak
1895.										
1,466	I.	6	7 1 1 P.M.	—	—	—	—	—	—	slight
1,467	"	10	3 43 5 A.M.	—	—	—	—	—	—	"
1,468	"	"	6 17 5 A.M.	—	—	—	—	—	—	"
1,469	"	11	5 53 30 P.M.	—	—	—	—	—	—	—
1,470	"	14	1 9 9 A.M.	—	—	—	—	—	—	—
1,471	"	18	9 14 3 A.M.	3 15	W.N.W.	0·9	1·4	0·3	0·2	quick, weak
1,472	"	"	2 54 35 A.M.	—	—	—	—	—	—	slight
1,473	"	"	10 48 24 P.M.	4 4	N.N.W.	0·9	4·1	0·7	11·0	quick, strong
1,474	"	"	11 17 4 P.M.	—	—	—	—	—	—	slight
1,475	"	19	0 20 44 A.M.	—	—	—	—	—	—	"
1,476	"	"	3 27 7 A.M.	—	—	—	—	—	—	"
1,477	"	"	9 43 55 P.M.	—	—	—	—	—	—	"
1,478	"	21	4 52 47 A.M.	—	—	—	—	—	—	—
1,479	"	"	8 29 22 A.M.	0 10	N.-S.	0·7	0·2	slight		quick, weak
1,480	"	"	7 31 22 P.M.	—	—	—	—	—	—	slight
1,481	"	"	9 19 28 P.M.	—	—	—	—	—	—	"
1,482	"	23	8 56 10 A.M.	—	—	—	—	—	—	"

CATALOGUE OF EARTHQUAKES—*continued.*

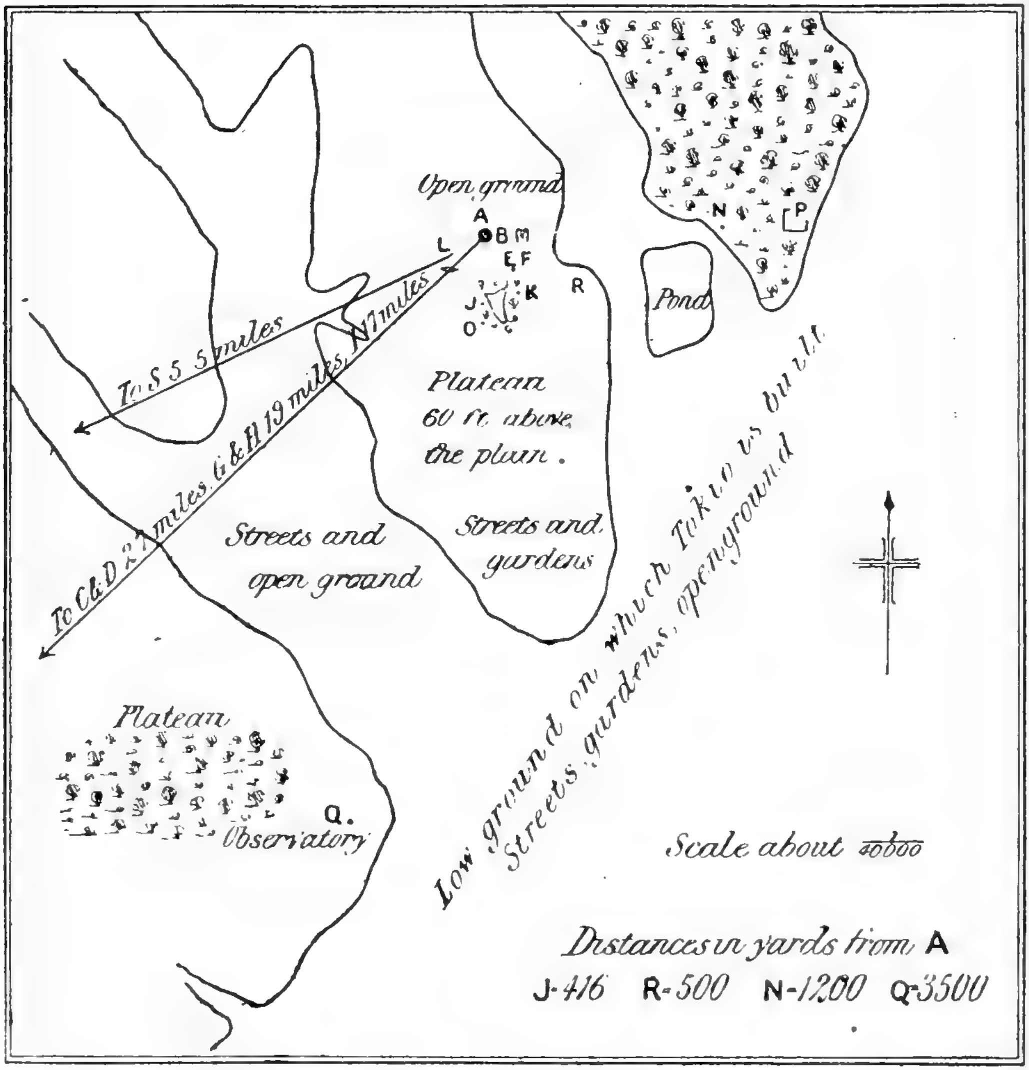
No.	Month	Day	Time	Duration	Direction	Maximum Period and Amplitude of Horizontal Motion		Maximum Period and Amplitude of Vertical Motion		Nature of Shock
						secs.	mm.	secs.	mm.	
			1895.							
			H. M. S.	M. S.						
1,483	I.	23	2 12 30 P.M.	2 10	N.-S.	0·7	2·4	0·6	0·6	quick, weak
1,484	„	24	8 30 9 A.M.	—	—	—	—	—	—	slight
1,485	„	25	11 44 42 A.M.	—	—	—	—	—	—	„
1,486	II.	3	1 49 15 P.M.	—	—	—	—	—	—	„
1,487	„	4	6 30 25 A.M.	—	—	—	—	—	—	„
1,488	„	5	1 46 36 P.M.	—	—	—	—	—	—	„
1,489	„	17	5 37 10 A.M.	—	—	—	—	—	—	„
1,490	„	18	0 52 0 A.M.	—	—	—	—	—	—	„
1,491	„	„	8 37 33 A.M.	—	—	—	—	—	—	„
1,492	„	23	11 3 26 A.M.	—	—	—	—	—	—	„
1,493	„	„	11 14 8 A.M.	0 12	E.-W.	0·9	0·2	—	—	slow, weak
1,494	„	28	10 39 28 A.M.	—	—	—	—	—	—	slight
1,495	III.	1	5 33 48 P.M.	—	—	—	—	—	—	„
1,496	„	3	4 14 50 P.M.	—	—	—	—	—	—	„
1,497	„	9	0 28 19 P.M.	—	—	—	—	—	—	„
1,498	„	15	7 19 52 P.M.	—	—	—	—	—	—	„
1,499	„	16	0 4 23 P.M.	0 58	E.-W.	0·8	0·4	—	—	—
1,500	„	20	1 5 26 P.M.	0 42	E.-W.	0·7	0·5	—	—	—
1,501	„	27	2 8 0 P.M.	—	—	—	—	—	—	„
1,502	„	30	3 35 39 A.M.	—	—	—	—	—	—	„
1,503	„	31	8 53 41 A.M.?	—	—	—	—	—	—	perhaps due to wind
1,504	IV.	2	3 12 34 P.M.	—	—	—	—	—	—	—
1,505	„	3	8 53 19 A.M.	—	—	—	—	—	—	—
1,506	„	3	7 49 44 P.M.	1 58	N.W.	0·7	1·3	0·6	0·3	—
1,507	„	4	1 41 32 P.M.	1 0	N.N.W.	1·2	0·5	—	—	—
1,508	„	5	3 10 0 A.M.	1 8	N.-S.	0·7	0·3	—	—	—
1,509	„	5	9 15 39 A.M.	—	—	—	—	—	—	slight
1,510	„	5	11 24 3 A.M.	—	—	—	—	—	—	„
1,511	„	6	4 32 36 P.M.	—	—	—	—	—	—	„
1,512	„	9	3 12 7 A.M.	1 8	N.W.	0·7	1·2	—	—	—
1,513	„	12	3 7 28 A.M.	0 52	N.N.W.	0·3	0·3	—	—	—
1,514	„	12	10 21 29 P.M.	—	—	—	—	—	—	„
1,515	„	13	10 41 46 A.M.	—	—	—	—	—	—	„
1,516	„	17	1 53 38 P.M.	—	—	—	—	—	—	„
1,517	„	22	7 9 3 A.M.	—	—	—	—	—	—	„
1,518	„	23	3 21 59 A.M.	—	—	—	—	—	—	„
1,519	„	25	0 16 19 A.M.	—	—	—	—	—	—	„
1,520	„	27	3 58 5 P.M.	—	—	—	—	—	—	„
1,521	V.	1	2 25 1 A.M.	—	—	—	—	—	—	„
1,522	„	2	4 15 7 A.M.	—	—	—	—	—	—	„

II. OBSERVATIONS WITH HORIZONTAL PENDULUMS.

(*a*) *The Instruments, Installation, Character of Movements.*

Since 1893 nineteen sets of records have been obtained from horizontal pendulums installed either in Tokio or its vicinity. In the following description the different installations or sets of instruments are indicated by letters of the alphabet. The instrument at A, which was in my house, occupied the same position from the commencement of the observations until February 17, 1895, when it was destroyed by fire. The instruments at other stations were kept in position until they had given continuous records for a period of from one to four months, when they were moved to a new locality. Although these periods may appear short, they seem to have been amply long to determine the general character of the movements to be expected at any given station. Instruments within a mile of my house were visited every day, while those at a distance—as, for example, at Kamakura (C and D)—were visited at least once a week. Notwithstanding the time taken in making journeys to the more distant stations, one of which occupied from ten to twelve hours, because the clockwork kept going for a week and the lamps burned for two or three days, it was often possible to keep six instruments working simultaneously. The notes and photograms for 1893 and 1894 obtained from stations A,

FIG. 1.—Map showing Positions of Pendulums.



E, F, C, D, G, H, and I, which were destroyed by fire, are fortunately described in the fourteenth report to this Association. In order to show the relationship of these observations to those made during the past year at A, H, I, and the remaining eleven stations, they are briefly referred to in the following notes.

The sensibilities of the different instruments which are described in the Report for 1894 are indicated by the number of millimetres the end of the boom was deflected by turning one of the screws in the bed plate one degree. The pitch of a screw was one millimetre, and its distance from the axis on which the bed plate was tilted may be taken at 220 millimetres. All the instruments excepting A had usually a sensibility of 1° for 3 mm., which is approximately equal to a tilting of 1″ for each millimetre of deflection. Occasionally the sensibility was increased twofold or threefold. The reason for this indefiniteness respecting sensibility is that the notes relating to the calibration of the instruments were burned. The chief value of these determinations is to give angular values for the diurnal wave, and because it will be shown that this is a quantity with large variations depending upon locality and weather, the necessity of accurate measurements becomes more apparent than real.

The Pendulum at A.—Sensibility, September 26, 1894. 1°=12 mm. or 1 mm.=0″·20. This instrument, which was adjusted to have a sensibility twice or six times greater than the other instruments, was installed in my private observatory on a massive well-built stone column resting upon a bed of concrete. Towards the east and west it was protected by 60 feet of building, but to the north and south by only about 10 feet. The only window in the room, which was on the south side, was always closed by a curtain on the inside and a solid shutter upon the outside. The reason that it was oriented to record N.E. and S.W. motions was because, as was explained in the last Report, there were reasons for believing that in such a direction earthquake and other motion had a maximum. The daily movements were often eclipsed or made indefinite by the occurrence of tremors. When they were visible, although on one occasion they were represented by deviations of 8 mm., it was rarely that they exceeded 2 or 3 mm. In many instances it seems that a second wave was superimposed upon the ordinary diurnal disturbance. Excursions towards the N.E. were usually completed between 5 and 15 hours, while the S.W. motion ended between 0 and 3 hours (fig. 6, p. 134).

Pendulums at C and D.—These were installed upon rock in a cave at Kamakura, about 27 miles distant from the pendulums in Tokio. One of these recorded motion in the direction of the dip of the strata, and the other in a direction at right angles to this. Their records are described in the Report for 1893–94.

Pendulums at E and F.—These pendulums were in directions N.E. and N.W. or parallel to C and D. The N.W. booms were parallel to A. The installation was in an underground chamber, where as at Kamakura the daily change in temperature was practically unappreciable. These records are described in the Report for 1893–94.

Pendulums at G and H.—The pendulums G and H were placed on the rock in a cave at the Yokohama Brewery. Their orientation corresponded to that of C and D or E and F, and their records are referred to in the above-mentioned Report.

Pendulum at I.—This pendulum was in an exceedingly damp cave at Kanagawa, about three miles distant from G and H. Its boom, like that of A, pointed towards the north-west. The few records obtained from this station are described with those of the above-mentioned three stations.

The Pendulum at J.—Sensibility, August 18, 1894, 1°=6·5 mm., or 1 mm.=0″·39. January 5, 1895, 1°=3 mm., or 1 mm.=0″·80.

This was an aluminium boom which, with its plate and index, had a total length of about 4 feet 9 inches. Its cast-iron stand rested upon a slab of slate upon the top of a short brick column, which rose from a layer of concrete covering a bed of gravel rammed into the natural earth. It was covered by a coarse wooden case. The whole arrangement was sheltered by a small wooden hut, 9 feet long and 7 feet broad, and up to the eaves 6 feet in height. This hut, like all the other huts, admitted so much light that the photographic films had to be changed at night. Currents of air came in freely, and, as might be expected, there were considerable fluctuations in temperature.

On the *west* side the ground was flat and open, and it was also fairly open towards the north and south. On the east side, however, it was sheltered by a small hill and trees, behind which came a pond, more trees, and then instrument K, which had a small tract of open ground upon its *eastern* side.

The westerly motion, which varied from 5 to 40 mm., usually took place between 18 or 21 hours and 6 or 9 hours, that is to say, the pendulum commenced to move towards the west at about 6 or 9 A.M., and continued this motion until 6 or 9 P.M. (fig. 7). During the night the easterly or return motion was gentle, and usually less than the motion towards the west.

On wet cloudy days no curves were visible.

Tremors were not marked at this station.

Comparing the N.E. and S.W. motions of A with the E. and W. motions at J in 24 instances these movements were completed at about the same hour. In 21 instances, however, there is a difference between them of from 5 to 10 hours.

An experiment which was made at this station was to dig a trench round the hut on its south and west sides. This was 5 feet in depth, while its distance from the column was about 10 feet. The only effect that this produced upon the daily diagram seems to have been that the points of inflection in the curve became somewhat sharper, the range of motion of the pendulum remaining constant.

Pendulum at K.—Sensibility, September 20, 1894, $1° = 4{\cdot}5$ mm., or 1 mm. $= 0''{\cdot}50$. November 21, 1894, $1° = 3$ mm. The installation of this instrument, excepting the fact that it was exposed to open ground towards the east and north, and sheltered by a grove of trees upon the south and west, was similar to that at J. The instrument itself was like that at J.

The diurnal movements had a range of from 4 to 40 mm. The westerly excursion usually commenced at 5 or 6 A.M., and continued until about 4 or 6 P.M. (fig. 8). The motion was therefore about one hour in advance of that at J, which roughly corresponds to the difference in time at which the ground in their respective vicinities were exposed to the morning sun. Comparing the hours at which the easterly and westerly motions of J and K were completed in fifteen cases, they closely agree. When these hours do not agree, K has usually reached its western limit from one to four hours before J. In two instances it completed this movement seven hours after J, while in two other cases one pendulum has been near its western limit, while the other has practically completed its movement in an opposite direction.

Tremors were not marked. The object in placing J and K, which were 275 yards distant from each other, on opposite sides of a small grove of trees, was with the expectation of finding that at the same time they moved in opposite direction. It is seen that the expectation was not realised.

Pendulum at L.—This instrument, which in construction is very like that at A, and is similarly oriented, stands beneath a wooden case on the concrete floor of a cellar in the north-western corner of the Engineering College at the Imperial University. It is without recording apparatus. Its pointer floats over a scale, and its position is noted every day about noon. When first set up on September 19, 1894, it had a period of 28 seconds. Its movements, which are indicated in millimetres, the sign + meaning displacement towards the west and − towards the north and east, have been gradual. They were as follows :—

1894.	During September	−1 or 2
	October 1–October 21	−2
	October 21–October 31	+2
	November 1–November 24	−7
	November 24–December 3	+7
	December 3–December 20	−2

Pendulum at M.—The object of this pendulum, which was installed upon the same column as A, was somewhat different from that of the others described in this series. It consisted of an aluminium boom loaded at its *outer* end with a weight of about 300 grms. In addition to this it carried a small vessel of ink from which a capillary tube projected, making the total length of the boom about 4 feet 6 inches. This tube was balanced, so that it barely touched the surface of a band of paper moving at the rate of about 8 inches per hour. The force required to deflect the boom one millimetre when applied at a distance of 4 feet from the agate pivot was approximately one milligramme. Before it was destroyed by fire it recorded the occurrence of several local earthquakes, and, considering its sensibility to tilting, it is probable that it would have recorded the gravitational elastic waves of disturbances originating at great distances. A necessary adjunct to such an apparatus in order to obtain an open diagram is the addition of a quick speed feed for the paper, which must come into action directly the pendulum commences to be deflected to the right and left of its normal position. Such a device was designed for me by my colleague, Mr. C. D. West, and it apparently works more satisfactorily than the original form of this kind of apparatus which is found in the Gray-Milne seismograph.

Pendulum at N.—Sensibility, January 5, 1895, 1°=3 mm. January 25, 1895, 1°=2·5 mm., or 1 mm.=1″·03. The pendulum used at this station was originally at K. The hut was situated on the western side of Uyeno Park, near to its southern extremity. It was sheltered by trees on its eastern and southern sides. On its western side, where it was open, there was a steep scarp leading down to the Shinobadzu Pond, which lies in the bottom of a flat open valley. A, J, and K were on the plateau on the opposite side of this valley, the heights of these stations being about 50 feet above the flat plain on which the greater portion of Tokio is situated. The movements were usually small, seldom exceeding 7 mm.

The westerly movement commenced from about 6 or 9 P.M., and continued until about noon next day ; that is to say, *that about the time when the instruments upon the opposite hill or plateau were going eastwards, the instrument at Uyeno went towards the west, and* vice versâ (fig. 10, p. 136).

Pendulum at O.—Sensibility, January 12, 1895, 1°=1·5 mm. January 22, 1805, 1°=1·5 mm. Station O was situated at a place about 20 yards to the south of J. It only differed from the instrument at this latter station in the fact that the boom of the pendulum pointed from west towards the east, and it therefore recorded north and south motion.

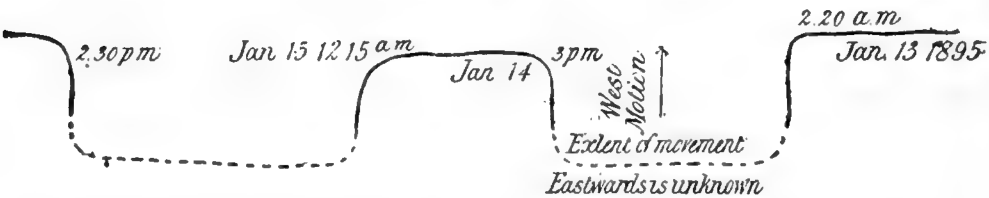
During the few weeks it was used, it showed a small but regular diurnal fluctuation, being farthest north about 3 or 5 P.M., and farthest south between 9 A.M. and noon (fig. 12, p. 137).

Pendulum at P.—Sensibility about the same as N. The instrument used at this station was the same as that used at N and K.

The hut faced an open space about 70 yards square on its northern side, but on all other sides it was shaded by high trees. For one or two hours about mid-day a few rays of sunshine reached the roof of the hut and the northern side of the open space. That the ground within 20 or 30 yards of the hut had but little sunshine may be inferred from the fact that after a fall of snow this remained upon the ground for ten or fifteen days. On open ground the snow disappeared in two or three days. During the day this would slightly thaw upon its surface, and at night it would freeze. About 50 yards to the east, a bluff sloped down to the Tokio plain.

Observations were only made between January 14 and February 4. The movements were extremely irregular, the most peculiar happening between January 14 and January 26. On these days, excepting the 23rd and 25th, during the night the pendulum made a rapid excursion towards the east, returning to its normal position some time about noon on the following day. These abnormal movements took place upon nights when

FIG. 2.



it was unusually cold, and therefore they may have been due to the freezing of moisture beneath or in the vicinity of the column (fig. 2).

Pendulum at Q.—This instrument, which is in charge of the Meteorological Department, is as well installed as the pendulum at A. It stands on a stone column in a dark room in the same building with a self-recording electrometer. The boom, which at first was partly made of lacquered bamboo, but which has been replaced by one of aluminium, points from north to south. Immediately outside the room there is one of the castle walls sloping down to a deep moat, beyond which comes the plain of Tokio.

The diurnal movements are slight, but decided, the westerly excursion being completed at from 3 to 6 P.M., and the easterly at about 6 A.M., which corresponds to the motions at J and K. Tremors are slight.

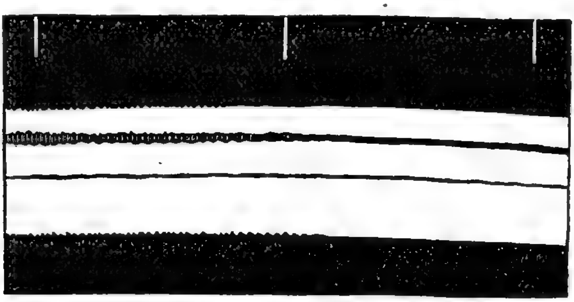
Pendulum at R.—This pendulum was set up in a hut in the garden at No. 17, Kaga Yashiki, Tokio. At a distance of about 5 yards on its western side a steep bank leads down to a road, which joins a second road at right angles on the north side of the hut, about 30 feet below the level of the garden.

The instrument is intended to act as a seismograph, sensitive to slight vibratory motions, while from the length of its boom, which is about 3 feet, it is also able to record slight changes in level. The first 2 inches of the boom is a small metal tube, at one end of which there is an agate cup. This boom is continued by a reed, at the end of which there is a black filament of straw. To balance the weight of the reed and straw a light arm, resting upon a pivot on the underside of the brass tube, carries at its extremities two small weights. Assuming the pivoted mass, which has a considerable moment of inertia and but little weight, to be the centre of oscillation of the system, which is held in a horizontal position by a thin wire tie, then the arrangement is that of a conical pendulum seismograph, having a multiplication of about twenty, and without the friction of a writing pointer. The black hair at the extremity of the boom floats above the slit in the box containing the drum, carrying the photographic film, which moves at a rate of 2 inches per hour. The resulting diagram is a white line showing the position of the shadow of the hair-like filament.

A modification of this instrument was to reduce the length of the boom to 2 feet, and because the trace given by the shadow of the filament at the end of the boom was wanting in sharpness, the filament was replaced by a thin plate of mica about half an inch square, with a small slit in its centre, similar to that used in the larger apparatus. Because the floating plate attached to the boom does not cover the whole of the slit in the box above the drum carrying the photographic film, the diagram is a black line given by the spot of light from the crossed slits, bounded on the right and left by a black band, the irregularities on the inside edges of which correspond with the irregularities on the central line. Every hour a separate clock depresses on one end of a balanced lever, at the other end of which there is a light vane which rises in front of the lamp, and cuts the light off for one minute. The result is that the central line (when there are no tremors), and the two bands at all times, are transversely marked by a distinct white line. Not only do the bands indicate time, and repeat the sinuosities and other movements shown on the central line, but by the presence or absence of striations they immediately show whether the clock driving the drum has been working regularly.

Instead of cutting off the light from the lamp, the light is now cut off the edge of the fixed slit by the hour hand of a watch moving horizontally across the same (fig. 3).

FIG. 3.



An experiment made at this station was to obtain diagrams on films, which only moved at the rate of 75 mm. in twenty-four hours, or 3 mm. per hour, which, from the results obtained, appears to be a suitable speed for recording diurnal waves and earth tremors (fig. 9). The western elongation is completed rather suddenly between 7 and 8 A.M. (nineteen and twenty hours). The eastern movement, which is performed with extreme irregularity, is ended about 4 P.M. The amplitude of this wave is about 30 mm.

During the day, or from 7 A.M. until about 9 P.M., tremors are absent, but they occur in a very marked manner between 9 P.M. and 7 A.M., when they suddenly cease (fig. 9).

The central part of fig. 3 shows a white band the width of a small plate of blackened mica at the end of a reed boom. In the mica there is a broad and a narrow slit, which correspond to the broad and thin lines in the diagram. The object of the broad line is to obtain a photogram, when the boom and its plate of mica are displaced rapidly, at which times sufficient light may not pass through the narrow slit to affect the bromide paper. When the motion is slow the fine slit gives the best definition. The vertical white marks at distances of 41 mm. apart are made by the prolongation of the minute hand of a watch crossing one end of the fixed slit every hour. If the instrument be disturbed at *known* times, and the times at which these disturbances took place be determined by the irregularities produced on the broad and thin bands, the errors in these readings vary between three and twenty seconds. Should the paper move irregularly, this is shown by differences in the length of the spaces representing hours, while the times at which retardation or acceleration took place are shown by vertical striations in the broad black bands. This is the form of recording surface which I am using to obtain photograms of movements due to earthquakes. It is not suitable for tremors or daily waves.

Pendulum at S.—This pendulum, originally at N, commenced its records on April 24, 1895, at the Agricultural School at Komaba, which is five and a half miles distant in a S.W. direction from the University. Komaba is situated on a flat plateau, and the nearest irregularity in the contour of the ground from the instrument which stands in the middle of a field partly covered with corn is at a distance of about half a mile, where there is a small valley. The soil is so light and dusty that a walking-stick may be pushed into it for a depth of two or three feet. Beneath this comes a red earth. The records show tremors, but they are small.

A westerly motion of about 5 mm. is completed at about eighteen hours, or 6 A.M., and an easterly movement of equal amount at about three hours, or 3 P.M. (fig. 11, p. 137).

On the S.E. side of the instrument the ground is bare, and during the day the pendulum moves to this side.

(*b*) *Daily Wave Records.*

In the following tables the localities or instruments are indicated by capital letters. The times at which an instrument completed its N.E., S.W., E., or W. excursion are indicated by hours, 0 or 24, corresponding to mid-day, and 12 to midnight. The figures in brackets give in millimetres the amplitude of the displacements. When a dash takes the place of hours it means that the displacements were too small to be measured, or that the diagram was a straight line. When the space for hours is left blank, it signifies that for some reason or other, either that no diagram was taken or that it has been lost. A record like 9–15 on October 15 means that the S.W. motion of A was completed between nine and fifteen hours.

Daily Waves.

—	A		J		K		Remarks
	N.E.	S.W.	E.	W.	E.	W.	
1894.							
October 13 .	9 [3]	19 [3]	12 [7]	23 [7]			
„ 14 .	6 [3]	19 [3]	6 [5]	23 [5]		5	
„ 15 .	3	9–15 [3]	irregular			6	
„ 16 .	15 [8]		„				
„ 17 .		21 [8]					
„ 18 .	3–6 [5]	15–21	18 [35]				
„ 19 .	very	slight		5–12 [35]		3–6	
			19 [15]		18 [25]		
„ 20 .	„	„		6 [15]		3–6	
			19 [8]				
„ 21 .				6 [8]	9	13	
			18 [18]		18 [12]		
„ 22 .	9	13		6 [18]		6 [12]	
	18	24	23 [14]	0	23 [18]		
„ 23 .	5	11	0	6 [14]		4 [8]	
	16	24	21 [5]		18 [12]		
„ 24 .	15 [5]	25 [5]		6 [5]	Irregular and broken		
			21 [18]				
„ 25 .	9	15		6–15 [18]			
	18	24	23 [6]				
„ 26 .	6			6 [6]		6	
			21 [6]		21 [4]		
„ 27 .				6 [6]	slight		
November 4			18 [15]		21 [40]		The deflections for A are too small and irregular to be relied upon.
„ 5		4		4 [15]		4	
	15		21 [18]		18 [40 ?]		
„ 6				6			
		18	15–21 [14]				J does not change much between 2 and 10, and again from 15 to 16 hours.
„ 7				6–9			
		18	21 [14]				
„ 8				6–12			
			22 [14]				The motion of K is more uniform without periods of rest.
„ 9				6–12			
			21 [10]				
„ 10				6–9			
			15–21 [18]				
„ 11			small				
„ 12			21				J no wave, but tremors at 21 and a westerly tendency.
„ 13	10	24		6–9			
			21 [20]				
„ 14	12	21		6–9			
			21 [19]				
„ 15				6			
			21 [19]				
„ 16				6–9			
			18 [15]				
„ 17				6			
„ 18				6			From 20th to 21st and 24th to 25th were times of rain, and J does not show a daily wave.
			18 [20]				
„ 19		4		9		5 [5]	
	12		24 [15]		12 to		
„ 20		7		0	22		
	12		0				With K from the 19th to the 20th at 22 hours where there was rain, the daily curve is absent or small.
„ 21		3 and 7		6		6	
	6, 14		19 [28]		18 [40]		
„ 22		3		6		3	
	17		19 [23]		15 [40]		
„ 23				9		2	
			21		15 [40]		
„ 24			0	0	no diagram		
			0	0			Machine K was moved to N.

DAILY WAVES—*continued.*

—	A N.E.	A S.W.	J E.	J W.	N E.	N W.	Remarks
				1894			
November 25							
			22				
„ 26		5		9 [30]	12–15		
	18		22			24	
„ 27				9 [30]	15		
			21			24	
„ 28		5		6, 12 [20]			
	18		9 [5], 21				
„ 29		6		9 [20]	15–18		
	12		24			24	The diagrams are fairly straight during a heavy tremor storm. With J no motion from 10 to 21 hours or during the night. The daily wave occurs during the time that the ground is unequally heated on the two sides of the hut.
„ 30				4 [12]			
			12				
December 2		4 [4]					
	24		21				
„ 3		4		9 [15]	9		
	15 [5]		21			24	
„ 4		6		5 [10]	8 or 9		
	15 [2]		12–20			24	
„ 5		19		5 [10]	6		
	15		12–20			24 ?	
„ 6		7		5 [10]	4–15		
	14	19	10–21			24	
„ 7	0			5 [10]	6	12	
			12–23				
„ 8			0	0		24	
			0	0			
„ 9		11	0		18–24		
	24		0				
„ 10		12	0			9–12	
	21		21				For J no daily wave from the 8th to the 10th at 21 hours when there was rain. Very little motion between 15 and 21 hours.
„ 11		5		6 [20]			
	18		19				
„ 12				6 [20]			
			18				
„ 13				5 [15]			
			15				
„ 14				8 [15]			
„ 16		6–12	straight				
	24						
„ 17		18		6 [12]	6–9		
	24		21			21–24 [3]	
„ 18	9	18–21		6 [10]	5		
			21			18–24 [5]	
„ 19		21		6 [10]	6–9		
			21			18–21 [4]	
„ 20			off the film		9		
			„			21 [4]	
„ 21	21		„		9		
			„			23 [4]	
„ 22		6–9	„		6–9		
						23 [4]	
„ 23				6 [20]	15	23 [5]	
			24				
„ 24				6 [20]	6		
			24			23 [4]	
„ 25		7		5 [12]	6		
			9–24			15–24 [7]	
„ 26				5 [12]	7		
			9–23			18–24 [7]	
„ 27				12–16 [21]	12–18		
			23			24 [3]	
„ 28	6		7 [3]	15–21 [5]		18–21	
		24	24 [5]				
„ 29					6		
„ 30			small				
	12					12–15	For J from 15 to 24 hours not much motion. The daily curves are sudden. N gives smooth flat waves.
		24					
„ 31			1	8 [12]	6–9		
			15			18–21	

DAILY WAVES—*continued.*

—	A N.E.	A S.W.	J E.	J W.	N E.	N W.	Remarks
1895.							
January 1 .	23		1	7 [10]	6		
			15			18–21	
" 2 .		9–12			5		
	24		23			21	
" 3 .		5		6 [15]	6		
	18		15			18–21	
" 4 .		5			5		
	12					18–21	
" 5 .							
" 6 .					6 ?	21	
" 7 .					6	15–21	
" 8 .					9	18	
" 9 .					straight		
" 10 .							

—	A N.E.	A S.W.	P E.	P W.	O N.	O S.	Remarks
January 14 .		6	On 13th at 14h. 20m. moved quickly eastwards off the scale. It returned on the 14th at 3h., but went off again at 12h. 15m. to return again next day at 2h. 30m. It left the scale again at 11h. 30m., and movements seem to have continued during the week, the pendulum being steady and on the scale from about 3 to 12 hours			18–21	The curious movements of P which are large displacements, taking 30 minutes or 1 hour for their completion, appear to have taken place on frosty nights. O gives a smooth curve with an amplitude of 4 or 5 mm.
	15	18			2–6		
" 15 .	0	5			0–3	18–24	
	14	19					
" 16 .	0	6				24	
	14				18		
" 17 .	0	8					
	16	24					
" 18 .							
" 19 .							
" 20 .	Up to the 20th the trace is practically a straight line		On the 20th it went quickly eastward at 7h. and returned to go westwards at 18h. 30m. Passed to the east on the 21st at 12h. 30m., and returned on the 22nd at 2h. 18m., when it was steady until 15h. 34m., when it went eastwards. It was steady from the 23rd to the 25th, when at 15h. it went again eastwards. Returned at 3h. on the 26th and remained steady		5	19	
" 27 .	0	0		7	0	21	The waves on O are decided and regular. It is difficult to determine the hour for the southern elongation.
			23				
" 28 .	18	24		8	3	12	
			12	19			
" 29 .	6	12		0	4	18	
	18	24	18	24			
" 30 .	9	18–21		0	3	21	
			15·5 off film				
" 31 .	—	—		23	4	15–18	
			—	—	—	—	Rain.
February 1 .	—	—		0	—	—	
			15				
" 2 .	no curves		12·15 off film towards east		diagram bad		
" 3 .			returned at 23 hours				
" 4 .			irregular and then no diagram				

(c) *Tremors, Microseismic Disturbances, or Earth Pulsations.*

In these tables the instruments or localities are indicated according to the letters of the alphabet. The hours between which tremors were marked are, for example, given thus, Oct. 13, 3 to 24. The times at which they attained a maximum range are given thus, max. 15 to 18. 0 or 24 indicates mid-day. The small figures in brackets give in millimetres the range of motion of the pendulum, as shown upon the photograms.

Date	A	J	K	Remarks
		1894.		
Oct.				
13	3 to 24, max. 15 to 18 (5)	From the 13th to the 21st very slight tremors, but there are three decided diurnal waves the easterly sinuses of which on the 17th, 18th and 19th coincide with the maxima of tremors. The largest wave coincides with the most pronounced tremors on the 18th	Slight tremors between the 18th and 19th only, and the easterly sinus of this day agrees with the records of J and the large tremors of A on the 18th	With the exception of the 13th when there was rain the large tremors and large waves occur on the fine days.
14	0 to 6 (2), 15 to 24 (2)			
15	0 to 6 (1), 12 to 24, max. 19 (3)			
16	0 to 3 (2), 18 to 24 (2)			
17	0 to 6 (2), 15 to 24, max. 19 (4)			
18	0 to 6 (2), 12 to 24, max. 19 (6)			
19	0 to 1 (1), 12 to 24, max. 22 (4)			
20	0 to 24, max. 18 (4)			
21	0 to 6 (0), 9 to 21, max. about 18 (5)	15 to 21, max. 19 (3)	14 to 17 (3)	On the 26th, 27th, and 28th, when there were no tremors, the daily curves of J and K are feeble.
22	12 to 24, max. 18 to 21 (10)	20 to 24 (2)	0	
23	0 to 3 (5), 8 to 24, max. 18 to 21 (10)	15 to 18 (2)	0	
24	0 to 4 (5), 6 to 24, max. 15 to 21 (15)	6 to 21, max. 18 (3)	Off scale	
25	12 to 24, max. 18 to 21 (10)	12 to 18 (2)	”	—
26	0 to 6, trace of trems. about 18	0	0	—
27	About 21 a trace	0	0	—
Nov.				
4	7 to 10 (4)	—	—	—
5	15 to 24, max. 15 to 21 (9)	9 to 18 and 21 to 23, slight	About 18 slight	—
6	0 to 3 and 9 to 24, max. 18 to 21 (12)	—	Diagram ceases after 6th	—
7	13 to 24, max. 18 to 21 (7)	12 to 21 (2)	—	—
8	15 to 18, max. 18 (3)	18 slight	—	—
9	18 to 23, max. 21 (3)	—	—	—
10	12 to 21, max. 18 (10)	—	—	—
11	12 to 24 small	9 to 21, max. 19 (2)	Slight	11th to noon of the 13th clouds and rain. Although there are no daily curves, tremors occur with the morning frequency. Tremors are marked while the pendulum is moving eastward and during its comparative rest of 15 to 21 hours.
12	0 to 22, max. 18 (10)	12 to 21, max. 18 (3)	No diagram	
13	12 to 22, max. 18 to 21 (8)	9 to 21, max. 19 (3)	—	
14	12 to 21, max. 18 to 21 (6)	12 to 19, max. 17 (2)	—	
15	13 to 22, max. 18 to 21 (5)	6 to 21, max. 18 (2)	—	
16	15 to 24, max. 18 to 21 (6)	6 to 16, also 21 to 24, max. 15 (2)	—	
17	0 to 6	0 to 6	—	Windy morning.
18	11 to 23, max. 16 to 21 (9)	6 to 18, max. 12 (2)	No record	—
19	17 to 22, max. 19 (4)	12 to 16, max. 14 (2)	12 to 16, max. 14 (2)	J and K for 19th to 20th no curve, but there are tremors.
20	8 to 11 (2), 18 to 21, max. 19 (3)	9 to 11 and 13 to 18, max. 17 (1)	6 to 9 and 16 to 17, max. 15 (2)	
21	18 to 21, max. 19 (2)	15 to 19, max. 18 (2)	0	For 20th to 21st on J no curve, but tremors.
22	15 to 23, max. 21 (2)	0	0	
23	18 to 23, max. 21 (4)	0	0	—
24	12 to 24, max. 18 and 24 (5)	0	0	—

TREMORS, MICROSEISMIC DISTURBANCES, OR EARTH PULSATIONS—*continued.*

Date	A	J	N	Remarks
		1894.		
Nov.				
25	0 to 21, max. 12 (4)	0	0	—
26	16 to 22, max. 19 (5)	max. 18 (3)	max. 18 (5)	—
27	No diagram	Off film	0	—
28	16 to 22, max. 19 (4)	max. 18 (3)	0	—
29	18 to 24	18 to 22, max. 21, (3)	18 to 22, max. 21 (3)	—
30	0 to 24, max. 15 to 21 (15)	0 to 24, max. 18 to 23 (3)	2 to 4 and 10 to 24, max. 18 (3), 22 (4)	—
Dec.				
1	0 to 24, max. 16 to 21 (10)	0 to 2 and 9 to 24, max. 2 (2)	0 to 3 (1) and 15 to 21 (1)	—
2	0 to 22, max. 0 to 18 (10)	0 to 20, max. 20 (2)	6 to 18 slight	Midday tremors at N might be due to traffic, but not those on the 3rd.
3	8 to 24, max. 18 to 21 (8)	15 to 22, max. 19 (2)	8 to 24, max. 12 (5) and 18 (5)	
4	12 to 24, max. 18 to 23 (8)	15 to 20, max. 19 (2)	0 to 4 and 21 to 24	
5	0 to 4 and 7 to 24, max. 17 to 21 (10)	Slight	0 to 6 (3) and 21 to 24 (3)	
6	12 to 24, max. 18 to 21 (8)	15 to 20, max. 18 (3)	15 to 24 (1)	—
7	12 to 24, max. 18 to 20 (8)	7 to 21, max. 14 to 18 (2)	0 to 3	—
8	13 to 24, max. 18 to 21 (4)	—	Slight at 23 (3)	—
9	11 to 24, max. 22 (6)	9 to 24 slight	0 to 24 intermittent up to 4	On the 9th up to midnight very many thousands of people were in the park and round the pond near N celebrating the capture of Port Arthur and the naval battle at Yaloo.
10	0 to 18 and 22 to 24, max. 12 (5)	0 to 18 slight, max. 18 (3)	0 to 17 (5) and boom held by a spider's thread	
11	0 to 6 (5) and 22 to 24 (5)	12 to 24 slight	" " "	
12	0 to 5, 9 to 23, max. 18 to 21 (5)	0 to 24 slight, max. 12 (2) and 18 (2)	" " "	
13	15 to 23, max. 21 (6)	12 to 15 slight	" " "	
14	0 to 8 (3) and 18 to 24 (4)	Slight	" " "	
16	0 to 24, max. 9 to 18 (10)	Slight	—	Tremors of N about midday may be due to traffic.
17	0 to 3 and 2 to 24, max. 18 (8)	9 to 18 (2)	21 to 24 (4)	
18	0 to 3 and 9 to 23, max. 15 to 21 (8)	0 to 21 slight	0 to 4 (2)	
19	12 to 22, max. 18 (7)	12 to 20, max. 16 (2)	18 to 21 (1)	—
20	15 to 22, max. 20 (6)	Off the film	23 (1)	—
21	16 to 22, max. 18 to 21 (5)	" "	0 to 4 (1)	—
22	15 to 21, max. 21 (4)	" "	21 to 24 (3)	—
	—	—	0 to 4 (4)	—
23	18 to 21 (2)	—	—	—
24	0 to 5 (4) and — to 23, max. 19 (4)	—	—	—
25	— to 23, max. 20 (10)	—	—	—
26	12 to 24, max. 18 to 21 (10)	—	—	—
27	0 to 5 (5), 7 to 12 (8), 15 to 24 (8)	—	—	—
28	0 to 24, max. 12 to 18 (10)	—	—	—
29	12 ? to 24, max. 20 (8)	—	—	—
30	6 to 24 (6)	Slight up to 21	— to 7	—
31	— to 24 (6)	Slight 12 to 23	15 to 23, max. 21 (3)	—
		1895.		
Jan.				
1	12 to 24, max. 18 (5)	Slight 9 to 23	15 to 21 slight	—
2	0 to 4 (3), 12 to 22, max. 18 and 21 (6)	9 to 21 (2)	12 to 18 "	—
3	15 to 24, max. 21	Slight 12 to 21	12 to 21 "	—
4	6 to 24 (6)	—	3 to 21 "	—
5	0 to 24, max. 19 (9)	—	—	—
6	12 to 18 (6)	—	7 to 24 (1)	The diagrams for N between the 6th and 13th were destroyed, and these records are from notes.
7	— 18 (6)	—	10 to 24 (1)	
8	15 to 24 (5)	—	12 to 24 (1)	
9	0 to 3 (2), 21 to 24 (1)	—	18 to 24 (1)	
10	0 to 3 (2), 10 to 24 (2)	—	0 to 24 (1)	
11	0 to 12 (1), 10 to 24 (1)	—	—	
12	0 to 3 (1), 15 to 24, max. 21 (5)	—	—	

TREMORS, MICROSEISMIC DISTURBANCES, OR EARTH PULSATIONS—*continued.*

Date	A	P	O	Remarks
		1895.		
Jan.				
14	0 to 3, 7 to 24, max. 18 (10)	Trems. during day of (2), but during the nights of the 13th, 14th and 15th, the light spot off the film	Very slight tremors on nearly all days	—
15	10 to 24, max. 18 (8)			—
16	13 to 23, max. 18 to 21 (5)			—
17	9 to 21 (2)		—	—
18	7 to 23, max. 19 (4)		—	—
19	15 to 23, max. 20 (4)	—	—	—
20	14 to 19, max. 18 (3)	Slight	—	—
21	12 to 24, max. 18 (4)	—	—	—
22	16 to 21, max. 19 (3)	—	—	—
23	0	—	—	—
24	18 to 24, max. 21 (3)	—	—	—
25	0 to 4, 9 to 24, max. 18 (5)	—	—	—
27	3 to 7 (1)	0 to 9 (5), 18 to 24 (5)	15 to 18 slight	—
28	3 to 6 (1), 15 to 23, max. 20 (2)	3 to 21 (2)	6 to 12 at 18 (2)	—
29	15 to 21, max. 19 (2)	12 to 21, max. 18 (2)	9 to 18 (1)	—
30	2 to 6, 11 to 22, max. 16 (5)	3 to 15 (2) then off the film	— to 18 (1)	—
31	No record, 18 to 22, max. 21 (2)	15 to 18 (1)	6 to 10 (1)	—
Feb.				
1	3 to 6, 18 to 23, max. 18 (3)	3 to 6 (2), 12 to 24 (2)	—	—
2	0 to 24 (3)	6 to 12 (2), then off the film	Slight tremors, but the diagram is bad	—
3	0 to 4 (2), 15 to 21, max. 18 (5)	0 to 24 (2)	—	—
4	15 to 21, max. 18 (5)	No diagram	—	—
5	14 to 20, max. 18 (3)	"	—	—
6	18 to 20, max. 19 (2)	"	—	—
7	18 to 24 (3)	"	—	—
8	0 to 4 (3), 15 to 21, max. 19 (3)	"	—	—

(d) *The Slow Displacement of Pendulums.*

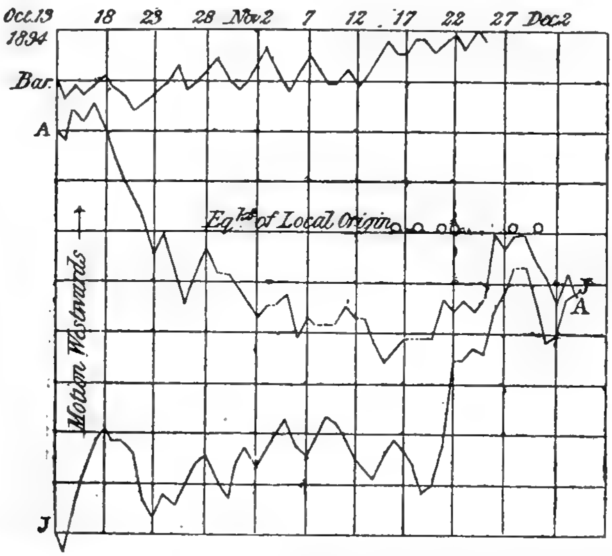
All my horizontal pendulums, whether they were situated upon the rock or upon the alluvium, have crept away from their normal position. While some of them have moved towards the east, others have moved towards the west. Irregularities like these have been noticeable upon newly built light foundations. Pendulums like those at A and L, where the foundations were massive and old, during the time that they were observed, had a general tendency to creep towards the west or south-west. These movements, which were often interfered with by permanent displacements caused by earthquakes, closely resembled the gradual displacements observed at stations upon the rock, where, for earthquakes at least, the yielding parallel to the dip of the strata was greater than it was in a direction at right angles to the same.

Although my intention when installing the instruments parallel and at right angles to the dip was to determine in which of these two directions yielding was the most pronounced, the observations were not continued sufficiently long to determine whether such changes as were observed had any connection with the secular movements which around Yokohama are apparently proceeding with unusual rapidity. To carry out this investigation, which would not be difficult for a resident at Kamakura, where caves are numerous, at least two installations would be required, and it is not unlikely that within a period of two or three years some measurement of geological changes would be obtained. I also regret to say that the duration of the observations was not sufficiently long to determine whether the wandering of the pendulums had an annual periodicity such as might be expected from the results obtained by observers in Europe.

(e) Periodic movements of several days' duration, and wandering of the pendulums.

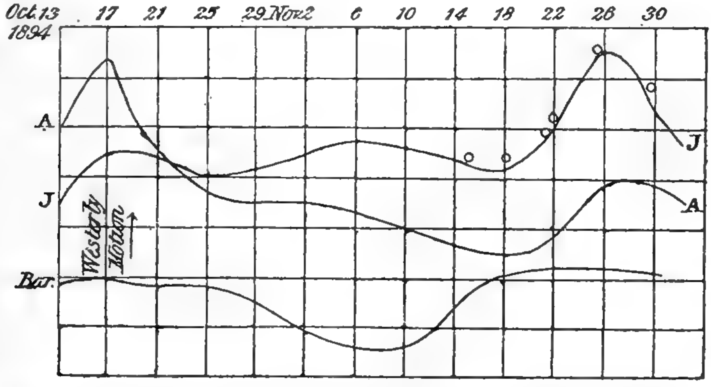
In order to determine the existence or non-existence of periodical movements greater than twenty-four hours, the mid-day position of instruments A and J were plotted on squared paper. This was done for dates between October 13 and December 4, 1894. Because the instrument at K during the period wandered so rapidly towards the east,

FIG. 4.



and had in consequence to be repeatedly re-adjusted, its records have not been considered. Whether the mid-day reading is the best one to represent the mean daily position of the instruments must for the present be left until a second examination of the diagrams has been made, when the analysis may be continued up to the end of the first week in February 1895 (fig. 4).

FIG. 5.



By drawing a free curve through the diagrams of mid-day positions of A and J, and reducing this horizontally and vertically one-fourth, the two curves shown in the accompanying figure are obtained (fig. 5).

During the complete period considered neither of the pendulums has changed much in its mean position. Whatever slight changes have taken place may be due to the direction in which the instruments or their foundations have warped, or, what is equally probable, they may each have moved away from an exposed area which, in consequence of evaporation, may have been rising. About this general movement of the pendulums which might be included in the previous section of this report, because it only refers to observations extending over fifty-two days with pendulums, one of which had a light foundation, no definite conclusions can be stated.

One thing, however, which is clear, and which can hardly be attributed to the warping of instruments or their foundations, is that the pendulums wandered at the same time in the same directions. For the first four days the pendulums at A and J moved westwards, for the next twelve days they moved eastwards, after which there was a slight westerly and then an easterly motion up to the fortieth day, when they both turned quickly westwards. This synchronism in direction of motion is evidently due to some general cause, which may act on the surface of the earth or within its interior. A barometric curve determined in a manner similar to that in which the curves for A and J were determined shows that atmospheric pressure was near its maximum when the pendulums were at their western limits, but the relationship between this curve and those of the pendulums is not sufficiently clear to conclude that the movements of the pendulums have been altogether due to fluctuation in atmospheric pressure. Possibly the movements may have been due to evaporation and precipitation lightening or loading some particular area in the vicinity of the pendulums.

The earthquakes of *local* origin indicated by circles on the curve for A, which occurred during the time that there was a rapid westerly motion, suggest the idea that the movements may have a hypogenic origin.

(*f*) *On the daily change in the position of the pendulums.*

The table below gives in millimetres the difference in the mid-day readings of the positions of the pendulums A and J. The sign + indicates that during the past twenty-four hours the pendulum has moved so many millimetres towards the west, while the sign − indicates a displacement towards the east. The sign ? means that no reading had been taken or that no displacement was observed.

1894	A	J	1894	A	J
October 14 . .	− 1	− 5	October 31 . .	− 2	+ 3
„ 15 . .	+ 5	+20	November 1 . .	− 3	+ 6
„ 16 . .	− 1	+ 8	„ 2 . .	− 2	− 6
„ 17 . .	+ 3	+ 12	„ 3 . .	+ 1	+ 1
„ 18 . .	− 6	+ 3	„ 4 . .	?	+ 8
„ 19 . .	− 4	− 3	„ 5 . .	+ 1	+ 5
„ 20 . .	− 4	?	„ 6 . .	− 8	−10
„ 21 . .	− 3	− 1	„ 7 . .	+ 4	− 1
„ 22 . .	− 3	−17	„ 8 . .	− 1	+ 6
„ 23 . .	− 8	− 7	„ 9 . .	?	+ 7
„ 24 . .	+ 5	+ 7	„ 10 . .	?	− 2
„ 25 . .	− 8	− 3	„ 11 . .	+ 3	− 3
„ 26 . .	− 6	+ 5	„ 12 . .	− 2	− 7
„ 27 . .	+ 7	+ 7	„ 13 . .	?	− 1
„ 28 . .	+ 4	+ 3	„ 14 . .	− 4	− 5
„ 29 . .	− 5	−13	„ 15 . .	− 3	+10
„ 30 .	?	− 4	„ 16 . .	+ 2	+ 1

1894	A	J	1894	A	J
November 17 . .	+ 2	− 1	December 3 . .	+ 6	+12
„ 18 . .	?	− 4	„ 4 . .	− 5	+ 1
„ 19 . .	−	−10	„ 5 . .	+ 1	− 2
„ 20 . .	?	+ 1	„ 6 . .	− 4	− 5
„ 21 . .	+ 7	+12	„ 7 . .	+ 2	?
„ 22 . .	− 2	+34	„ 8 . .	− 1	− 3
„ 23 . .	+ 2	?	„ 9 . .	?	−10
„ 24 . .	− 1	+ 3	„ 10 . .	?	?
„ 25 . .	+ 2	− 1	„ 11 . .	+11	+ 9
„ 26 . .	+12	+16	„ 12 . .	− 2	− 4
„ 27 . .	− 2	+ 8	„ 13 . .	− 4	?
„ 28 . .	+ 2	+ 9	„ 14 . .	+ 3	− 6
„ 29 . .	?	?	„ 15 . .	?	+ 4
„ 30 . .	− 5	−15	„ 16 . .	− 1	+ 4
December 1 . .	− 2	−12	„ 17 . .	?	− 7
„ 2 . .	− 5	+ 1			

An inspection of this table shows that, although the pendulums A and J were separated by a distance of about 270 yards, and were differently installed, there has been a general agreement in the direction of their displacements, and that this is particularly marked when the movements of A were decided. When there has been disagreement in the direction of motion, the movements of A have usually been small, and it is not unlikely that such discrepancies would disappear if a time had been taken to represent the daily mean position farther removed from the hour at which the western movement of the diurnal wave commences. The changes indicated in the table are also shown diagrammatically in conjunction with a curve showing the fluctuations of the barometer (p. 129).

What is true for A and J is generally true for J and K. Although between October 13 and November 20 there are six decided barometrical fluctuations, and during the same interval there are six decided westerly movements of J, the crests and depressions of these diagrams do not retain the same relative position. For example, on October 17 the barometrical crest corresponds to the westerly extension of J, while on November 5 a similar movement of J corresponds to a barometrical depression. Although at times it appears as if there were a close relationship between barometrical fluctuation and the movements of the pendulums, the diagram (fig. 4) indicates that, although both phenomena are nearly identical in having a periodicity of between two and seven days, it does not show that they are absolutely synchronous. It seems that the instruments at J and K, which were within six feet of exposed ground, with or after rain moved westwards, but equally large westerly motions have occurred without rain.

g. On the Diurnal Wave.

In considering the results towards which the observations of the daily wave point, it is necessary to consider the observations made during the past year in conjunction with those described in the Report for 1893-94.

When instruments were installed upon the rock in caves as at Kamakura (C and D), at Kanagawa (I), and in Yokohama (G and H) the daily wave was not perceptible. This by no means precludes the possibility of its existence in such places, and had instruments of greater sensibility been employed it is likely that it might have been detected. It was perceptible and often measurable, but by no means pronounced in the records from my house (A), where the instrument was well founded and in an east and a west direction, well protected from temperature effects upon the surrounding soil. It must not be forgotten that this instrument was the most sensitive, being capable of recording changes of 0″·1. Had the sensibility of this instrument not exceeded that of other instruments less favourably installed, it is doubtful whether it would have shown any marked trace of the daily wave.

Two instruments in an underground chamber (E and F), where as in the caves the daily change in temperature did not exceed 1° C., often showed the daily wave in a marked manner, but it was not so great as it was at stations J and K upon the surface. The conclusion to which these observations lead is that the daily wave is not due to fluctuations in temperature immediately near to the instruments, but that it is a surface phenomenon which penetrates to a depth of at least 12 feet in the alluvium.

An instrument upon the surface (J) the ground round which was exposed to the sun upon all sides excepting the east, and another (K) which was exposed on all sides excepting the west, showed large diurnal waves, and notwithstanding the fact that between these two stations there was a pond and a grove of tall trees, the pendulums usually moved in the same direction at about the same time. The magnitude of the movements was different, but with this exception the only other difference was that J, the open ground round which was exposed to the afternoon sun for one or two hours longer than the open ground round K, continued its westerly motion for one or two hours longer than K (figs. 7 and 8).

An experiment made at J was to dig a trench 5 feet in depth round the south and west sides of the hut. This did not appear in any way to affect the amplitude of the daily wave, but it seemed to increase the suddenness with which the westerly displacement commenced, and at the same time the number of hours occupied in making a complete wave was reduced. With an instrument at O, a few yards from J, which recorded north and south motions, the wave was regular but of small amplitude, the northern movement coinciding with the western motion of J and K. The direction of maximum tilting may therefore have approximately been W.N.W. and E.S.E. On the western side of a plateau facing the eastern slope of the plateau on which A, J, K, and O were situated, an instrument N showed a daily wave, but *the westerly excursion of the pendulum was completed only a few hours later than the easterly excursion was completed by those upon the opposite hill.* It appeared as if the two bluffs, or at least the trees upon them, inclined towards each other, and then away from each other once in twenty-four hours. Between the two bluffs there is an open valley, in which there is a lake or pond nearly half a mile in breadth.

That the records at N were small may be attributed partly to the fact that the instrument never had given to it any great degree of sensitiveness, and partly to the fact that on all sides excepting the west the ground immediately round the instrument was well shaded by tall trees. There is, however, a large open space about 100 yards to the east of this station. At another station P, on the eastern side of the plateau, on which N was situated, and at a distance from it of about 200 yards, the movements, especially upon frosty nights, were extremely erratic, and they may probably have been produced by the freezing of the ground. When the cold was not great the movements were small, and here, again, the ground around the instrument was so well shaded by trees that after a snow-storm it would take from ten to fifteen days to melt away the snow, which at other places disappeared in one or two days. At Q, R, S, and O the movement during the day was towards the side on which the ground *near* to the instruments was most exposed to the sun.

One very important observation especially marked at stations where large diurnal waves were recorded was that *on rainy or cloudy days these instruments were steady, and no diurnal wave was recorded.*

The general conclusion to which these observations on the diurnal wave point is that on the alluvium on open ground, the daily wave is most pronounced on the surface, it is less in amplitude, but it may be decided at a depth of 12 feet ; while on a massive foundation the ground round which is well protected by a building or trees the wave is slight. Deep underground on a rock foundation with instruments such as I have had at my disposal it is not perceptible, but it is not improbable that a residual effect of the surface motion might be detected with more delicate apparatus. The cause of the motion is not any immediate effect of temperature upon the instruments, nor if we except the case where actual freezing of moisture in the ground round and possibly inside one of the huts took place does it appear to be due to expansion or contraction in or near the foundations accompanying the acquisition or withdrawal of heat.

The most active cause producing the movement which takes place during the day may be the fact that the ground on different sides of an instrument is unequally exposed to effects producing evaporation. The retrograde motion during the night, which is smaller and more gentle than that which has happened during the day, may be due to the unequal condensation of moisture on two sides of a station.

1. *Effects accompanying Evaporation* (*Daylight Effect*).—As the side of a station from which most moisture is withdrawn to be dissipated in the atmosphere has been relieved of a load, we should expect it to rise, and this effect ought, in alluvium, to be perceptible to some depth. The same area, because it is contracting like a drying sponge, may sink, but this would be a superficial action.

On open ground, under favourable circumstances, the load taken away from a surface of earth by evaporation may amount to 4 or 5 lb. per square yard, or from an area 20 yards square, about 1 ton. Experiment has shown that 2 tons of water taken out of a well and run off down a hill will cause a pendulum at a distance of 20 or 30 yards to behave as if the ground upon the well side had risen. If these premises are correct, then an instrument well surrounded by trees or buildings, because the evaporation is slight and is not likely to be much more marked upon one side than it is upon another, should show but little motion. A pendulum at a station freely and uniformly exposed upon all sides should also show but little change. During the morning a north-south pendulum would be expected to move slightly towards the west. For some hours after the sun's meridian passage there would be a pause in such displacement, after which a retrograde motion would set in. An instrument with open ground upon its eastern side would, during the morning, be expected to move westwards ; while at the same time another instrument, with the western side as an evaporation area, would move eastwards. It

FIG. 6.

A.—Moves west from 3 A.M or 6 A.M. to 3 P.M., or from noon to 9 P.M., or midnight.

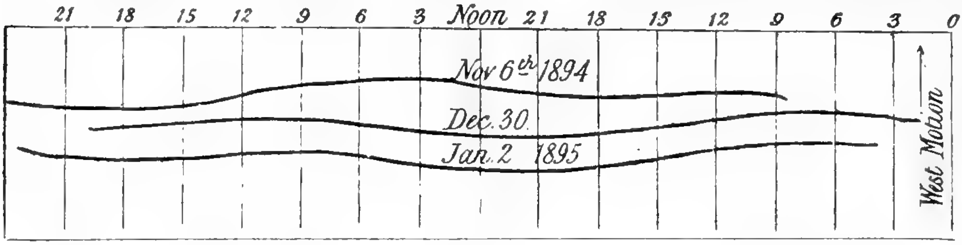
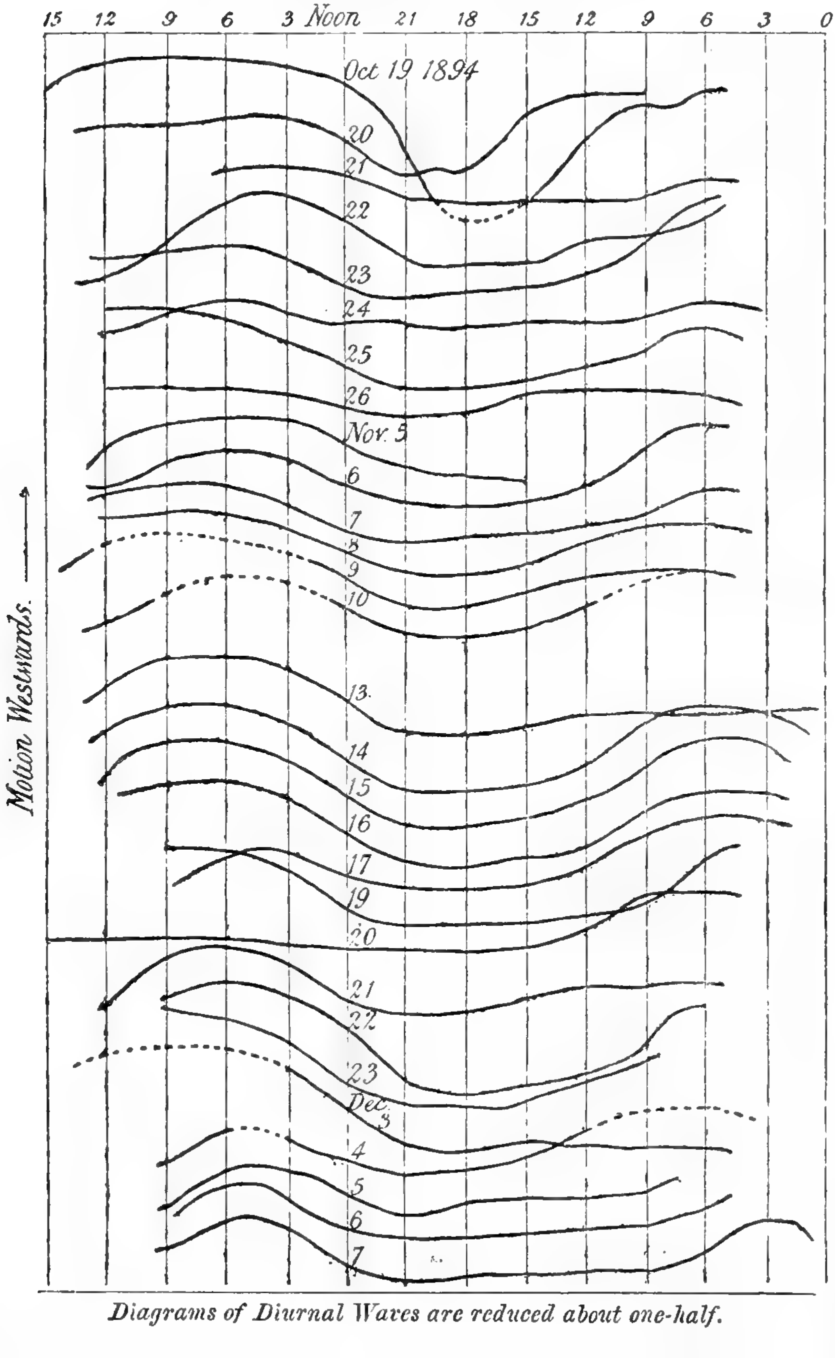


FIG. 7.

J.—Moves west from 6 A.M. to 6 or 9 P.M.



Diagrams of Diurnal Waves are reduced about one-half.

is not likely that pronounced movements would be recorded upon rock, neither should there be an appreciable trace of diurnal waves on days when it was wet or cloudy.

2. *Contraction due to Desiccation.*—If the desiccation due to heating by the sun is followed by contraction, we should expect that during the day a pendulum would move towards the side losing the greatest amount of moisture; that is to say, its movement would be in a direction opposite to that accompanying the removal of a load due to evaporation. On ground covered by trees or buildings, or on ground uniformly open all round, but little motion should be expected. Whatever effect was observed it is not likely that it would penetrate many inches beneath the surface.

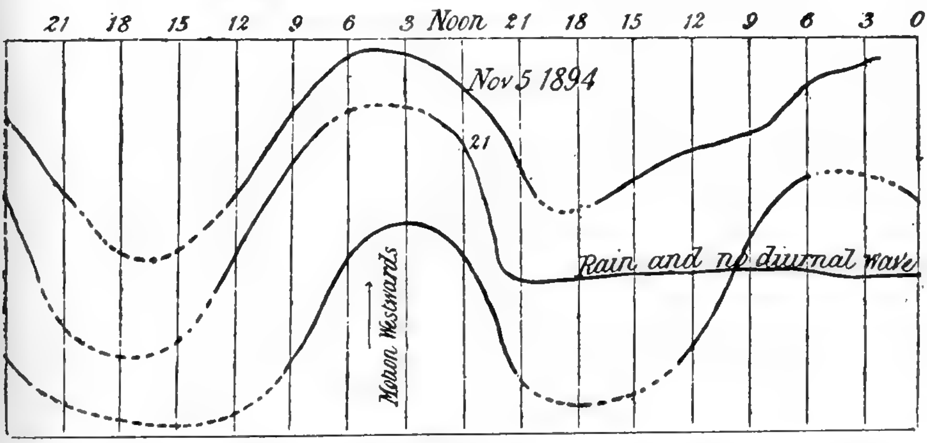
The following is a comparison of these considerations, with the observed movements of the various pendulums and the character of the surrounding ground.

For 100 yards to the east and west of A the ground is equally open. The most open ground, however, lies to the east. It would therefore be expected that movement during the day due to unloading would be westwards. The observed movements, however, although generally westwards, showed too many irregularities, and were too feeble to justify a conclusion that they were due to such an influence (fig. 6).

For 100 yards round station J the ground is more open upon the western side than upon the eastern side, and the westerly motion might therefore be attributed to desiccation and contraction upon this side. Beyond this limit, however, the ground is most open upon the eastern side, which might therefore, by evaporation, rise. This would give a westerly motion (fig. 7).

FIG. 8.

K.—Moves west from 6 A.M. to 3 or 6 P.M.

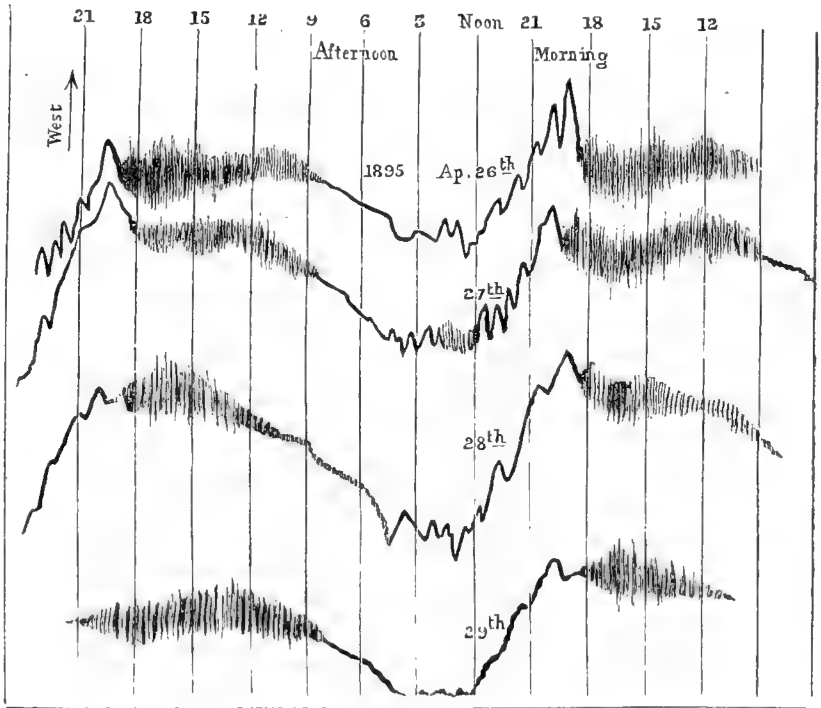


For 100 yards round K the ground is most open upon the eastern side, and desiccation would result in an eastern displacement. The westerly motion recorded seems to find its only explanation in the fact that the eastern side of the instrument is more open than the western side, but the reason that these movements were greater than those at J is not clear (fig. 8).

Immediately to the west of R there are tall trees and a deep cutting. So long as the sun shines over these trees upon an area 50 or 100 yards long to the east of the instrument, the pendulum moves towards the area which is drying. Beyond this limit, however, there is far more open ground on the N.W., W., and S.W. sides of the station than there is in opposite directions, and the pronounced easterly motion may therefore be due to the unloading on the western side (fig. 9).

FIG. 9.

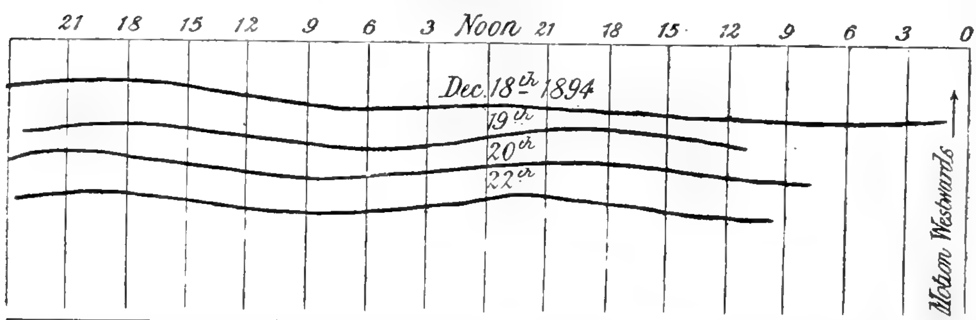
R.—Moves east from 8 A.M. to 3 or 4 P.M.



All round station N for a distance of at least fifty yards there are either high trees or shrubs. Beyond this limit in a westerly direction but at a lower level there are a pond and flat ground. In an opposite direction

FIG. 10.

N.—Moves east from 9 A.M. to 6 or 9 P.M.



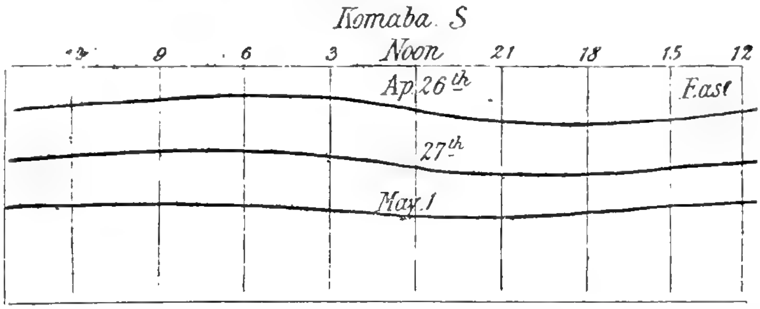
on the same level there is at a distance of about one hundred yards a smaller area of open ground facing the Exhibition buildings. The movement is therefore as if the ground on the side of the largest evaporation area had arisen. But the movement is small (fig. 10).

Near to the instrument at S on the west side the ground is covered with green corn about one foot in height, while towards the S.E. there is a strip of bare ground perhaps fifty yards wide and one hundred yards in length. The movement, which, however, is slight, is towards the area most open to the sun.

Neglecting this strip, then, there is very much more open ground on the western than upon the eastern side of the station, and the movement may be explained on the assumption that this side, because it loses the most weight, rises relatively to the other (fig. 11).

FIG. 11.

S.—Moves east from 6 A.M. to 3 P.M.

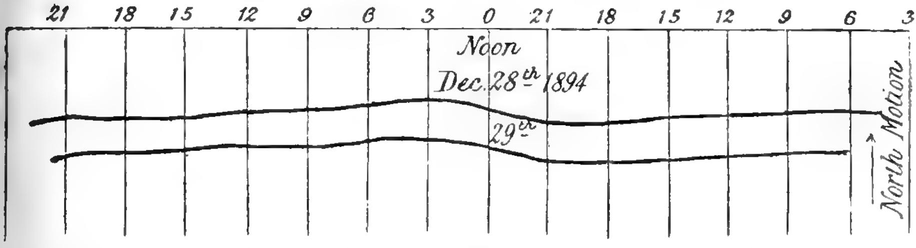


Near to O the ground is somewhat more open on the north side, and it would appear that the motion was towards this side. Because the movements are slight, they might equally well be explained as a component of a south-eastern tilting due to greater relief of load upon the S.E. side, which is more exposed than that in the opposite direction.

Although a diagram may be modified by contraction following desiccation in the immediate vicinity of an instrument, this detailed examination of the observations in relation to the localities at which they were

FIG. 12.

O.—Moves *north* from 9 A.M. to 5 P.M.



made tends to the conclusion that diurnal waves are in part distortional effects of the earth's surface due to unequal relief of load from various areas by evaporation. When the movements have been absent or small, the instruments have been, at stations on the solid rock, well protected by trees or on an open plain. Many anomalies occur which still require an explanation, the most remarkable perhaps being the smallness of the motions at A, where the hypothesis requires that they should have been pronounced. The intermittent character in the movement at R may possibly be connected with the deep cutting on its western side, which breaks the continuity of the ground upon that side, which it is assumed in order to produce the easterly deflection must rise.

I put forward these conclusions simply as being, for the present at least, the best that I am able to arrive at as explanatory of my own observations. The conclusions reached by Dr. E. von Rebeur-Paschwitz only partly confirm my results. In the British Association Report for 1893, on p. 316, he says that 'the range of motion is on an average very nearly proportional to either the quantity of sunshine or the maximum oscillation of temperature during the day.' This and the fact that the movements at Teneriffe, where the observatory appears to have been founded on and surrounded by soil and rock, were very much more pronounced than they were at Potsdam and Wilhelmshaven, where the soil was comparatively soft, apparently support the view that the diurnal wave may be a distortional effect due to evaporation. On p. 320 of the same report, however, he says that 'at Potsdam as well as Orotava the average range of daily motion agrees most remarkably with those meteorological elements which we may consider as a measure of the intensity of solar radiation. But I must not omit to remark that the single days do not show this coincidence equally well. For cloudy days occur with a large range of oscillation, and clear days with a small range.'

Although my observations in Japan have shown that when it was cloudy and wet the diurnal wave has been absent, it is not impossible that there may be cloudy days when, in consequence of wind, evaporation may occur, and in consequence the daylight distortion may be marked.

3. *Effects due to Condensation* (*Night Effect*).—It has been shown that at a favourably situated station the evaporation effect which has been marked during the morning may late in the afternoon be the means of starting a retrograde movement. It, however, remains to be explained why a motion possibly commenced in this manner continues slowly during the night until about 6 A.M. upon the following morning. Because this movement is comparatively small it may be produced by the addition or removal of a comparatively small load.

The precipitation of dew, which on a uniform area like evaporation follows in the wake of the sun, represents a feeble load, but the retrograde motion continues when dew is not visible. But although dew may not be visible, if we look beneath a board which has been lying on the ground all night it is usually found to be very wet. This observation suggested the idea that just as moisture is condensed beneath a board, so it may be condensed in the ground within one or two inches of the actual surface.

During a hot day moisture is evaporated from the soil, which is perceptibly heated to a depth of about one foot. Shortly after sunset the surface to a depth of one or two inches is chilled or in winter it is frozen. The result of this is, that moisture rising as vapour and by capillarity from water-bearing strata is condensed on the underside of the chilled surface. Like the dew we see on a uniformly covered surface the underground dew should be first precipitated on the eastern side of a station and subsequently upon the western side, and therefore during the night the surface on the former side gains weight at an earlier hour than the latter.

To determine how far superficial soils gain in weight by an action of this description, independently of moisture precipitated from the atmosphere or condensed as it rises out of the ground, the following experiments were made. Two boxes each 1 ft. 6 in. square and 2 in. deep were balanced on the extremities of beams carried upon knife edges. One box had a bottom made of tin and the other of fine wire netting, and each was filled with earth. Excepting when they were weighed, by placing weights at the other ends of the beams, they were allowed to rest on the soft earth of my garden. Sometimes it was found that during a night both boxes would lose weight, but at other times it was found that the weight of the box with the tin bottom had not changed, whilst the one with the wire netting had gained from 2 to 2·5 ounces, which apparently showed that there had been a condensation of moisture coming up from beneath of 10 ounces per square yard, or about one-eighth of that which might have been removed during a day by evaporation. As my notes upon these experiments were destroyed by fire, what is here said can only be taken as indicating the character of a phenomenon which hitherto has not received attention.

Whether the causes which have been described are sufficient to account for the diurnal movements of a horizontal pendulum remains for future investigators to decide.

The gradual taking away of weight, followed by a gradual addition of weight unequally on the two sides of a pendulum during each period of 24 hours, will account for the observed movements, and in the evaporation of moisture during the day and the precipitation of moisture on the surface, together with its condensation beneath the surface during the night, we have phenomena which relieve or load surfaces in the required manner.

(*h*) *Tremors.*

In the third Report to the British Association, 1883, after observing tremors with the ordinary Italian form of tromometer, I attributed their origin either to the effects of high winds or to small but rapidly recurring variations in atmospheric pressure, such as may be observed during a typhoon.

After analysing a long series of records of these movements, which were obtained from an automatic tremor recorder, and comparing the results with observations made in Italy, the conclusion arrived at was that tremors were at a maximum when the barometrical gradient was steep, no matter whether at the place where the tremors were observed the barometer was high or whether it was low.

This relationship between tremors and the state of the barometric gradient, although it did not explain the origin of tremors, tended to destroy the distinction between tremors which occur with a low barometer, and are called *baro-seismic* motions, and those which appear during periods of high pressure, which are called *volcano-seismic* disturbances.

An examination of the photograms obtained from the horizontal pendulums, which permit of more accurate analysis than those previously obtained, although it does not show that tremors only occur at the times when the barometric gradient is steep, shows that at such times tremor storms are marked. These same diagrams, however, on account of the relationship they show between tremors, the changes in the position of a horizontal pendulum, barometrical pressure, and the diurnal wave, lead me to withdraw the suggestion that, because steep gradients are usually accompanied by wind, such winds, whether they are local or distant, may be the immediate cause of tremors. In their times of occurrence winds and tremors undoubtedly show a close relationship, and therefore the former may, by its mechanical action upon buildings, trees, and the surface of a country, produce *slight* tremors, and influence the character of a record.

The points which are marked in connection with the recent observations are as follows :—

1. *Relationship of Tremors to Localities and Instruments.*

Tremors have been pronounced at Station A, the instrument at which station, however, was the one most sensible to changes of level. At stations on the surface in Tokio they have been feeble, but have varied in their intensity. Underground upon the rock they have never been observed. This latter observation, which is based upon records obtained from five instruments, is in direct opposition to the observations made at Rocca di Papa in Italy, where, I understand, tremors are as pronounced underground as they are upon the surface.

At Station A, an instrument which showed tremors even in a more marked manner than the large horizontal pendulum, was a similar instrument made of a few millimetres of aluminium wire, a small mirror, and a needle point, weighing only a few grammes, a comparatively large form of which is described in the Report for 1892. On account of the manner in which the spots of light reflected from the mirrors of a pair of these instruments placed side by side would come to rest, and then start suddenly to move in the same direction, I was led to the conclusion that they were actuated by an intermittent tilting, and therefore that tremors, rather than being elastic vibrations, had the character of wave-like undulations.[1] The fact that the instrument most sensitive to changes of level gave the most pronounced records appeared to strengthen this supposition, and I was led to call these movements earth pulsations.

The only effect produced by heavy gusts of wind striking the building, or the beating of a steam hammer at a distance of fifty yards, is to produce a temporary vibration in the pointers of an instrument ; but there is no angular displacement, and consequent swing, which characterises the movements during a tremor storm.

An important observation made at Station A was that tremors were produced when two tons of water were taken out of a well distant about thirty yards. The operation caused the ground upon the well side to rise, and the horizontal pendulum was gradually displaced in an opposite direction. From this it may be inferred that either the pendulum took up its new position intermittently, or that the level of the ground changed intermittently. Whichever it may have been, it may be concluded that whenever a rapid change in the inclination of the ground takes place, horizontal and probably other pendulums may be caused to swing, and, as will be seen in the next section, at least a portion of the tremor records may be explained on the supposition that they are due to such causes.

2. *Relationship of Tremors to the Diurnal Wave.*

(1) Even when a horizontal pendulum is steadily following the diurnal wave and no tremors are visible, slight tremors nearly always appear about 6 or 9 A.M., just at the time when its easterly excursion has been completed and it turns to commence a relatively rapid motion towards the west (figs. 9 and 13).

[1] The instruments were under the same cover. See Appendix.

(2) Should there be a tremor storm extending over one or two days there is a maximum motion at about 6 or 9 A.M. (figs. 9 and 13).

(3) Large daily waves nearly always correspond with pronounced tremors (47 cases).

(4) When no daily wave appears, or when it is feeble, which usually happens when the weather is dull or wet, there have been eight cases of feeble tremors, and nine cases where tremors have been practically absent.

(5) The greatest motion is experienced, or motion is most frequent, while the pendulum is moving eastwards—an observation which is connected with the remarks in the next section.

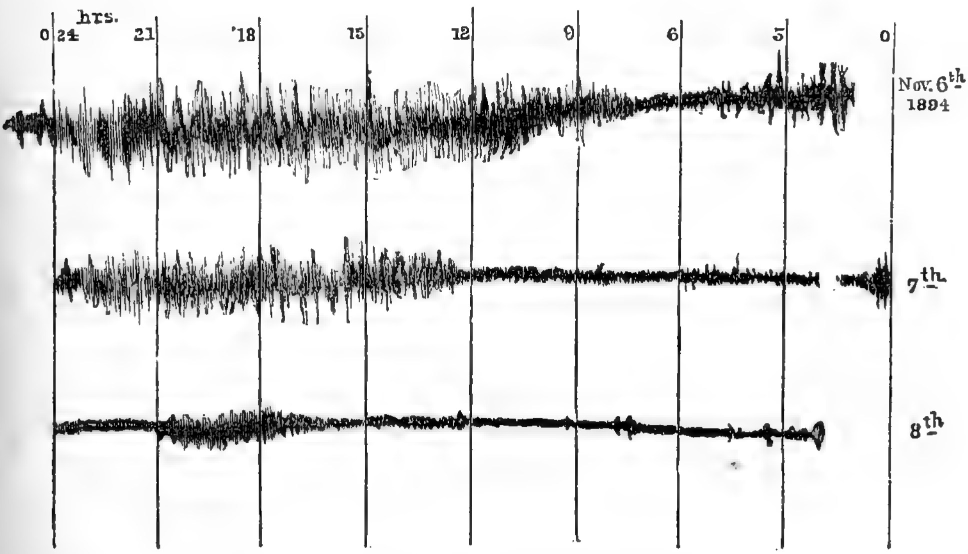
3. *Relationship of Tremors to the Hours of Day and Night.*

(1) It has been shown that tremors are most frequent or at their maximum at about 6 or 9 A.M. (figs. 9 and 13).

(2) The hours during which storms are the most frequent are from 9 P.M. or midnight until mid day. During the afternoon and evening, therefore, tremors are not so frequent.

(3) The tremors at 6 or 9 A.M. may be attributed to irregular movements accompanying the reversal in the inclination of the ground which

FIG. 13.



takes place at these hours, but if the tremors which occur at night are to be attributed to an intermittent change in level, it then becomes necessary to explain why the smallest changes in level are most intermittent in their character, which supposition is improbable. The accompanying figure shows how a tremor storm which may continue over several days has a maximum at 6 or 9 A.M., and also, as it dies out, that it terminates with slight tremors at these particular hours. It is taken from instrument A.

4. *Relationship of Tremors to Barometrical Conditions.*

(1) Tremors are apparently as marked with a high barometer as with a low barometer.

(2) Tremors chiefly occur with steep barometric gradients.

(3) They are marked when barometric changes are rapid, whether the barometer is rising or whether it is falling.

(4) Although it is not likely that the daily fluctuation of the barometer should have any marked effect upon the production of tremors, it may be noted that the maximum of tremors occurs when the barometer is at its greatest height and about to fall rapidly to its daily mimimum. Mr. T. Wada, of the Meteorological Observatory, has kindly given me the following table showing the daily barometrical maxima and minima deduced from eight years' observations :—

—	Fluctuation	Maxima	Minima
	mm.	Hour	Hour
Winter	2·23	9 A.M.	2 P.M.
Spring	1·91	9 „	4 „
Summer . . .	1·35	8 „	4 „
Autumn . . .	1·74	9 „	3 „

For the year 760·00 – 758 30 = 1·70 mm., at 9 A.M.

5. *Relationship of Tremors to Wind, Temperature and sub-Surface Condensation.*

Although tremors have occurred when a heavy wind was blowing in Tokio, as, for example, on October 26, tremors have been marked when wind was practically absent. Neither does there appear to have been any marked connection between the occurrence of tremors in Tokio and the wind at Chōshi, which is situated on the coast about 50 miles west from Tokio.

Although the morning breeze is apparently stronger than that in the evening, it does not seem to be connected with the morning frequency of tremors.

Tremors are most frequent at the hours when the temperature is lowest, or during the time that sub-surface condensation is taking place. Tremors are at a mimimum during the time that the ground is becoming heated, and there is a free flow of moisture in the form of vapour from the earth to the atmosphere.

Tremors and Waves on the Coast.—At the various lighthouses round the coast of Japan at 2, 6, and 10 A.M. and P.M., records are made of the force of the waves. In these records 0 = calm and 6 = waves, which are unusually large. I have compared the records from Jogashima, 33 miles south of Tokio, and Inuboye, 53 miles west of Tokio, with the records of tremors, but I do not observe any connection between them (see Tables).

Occurrence of Tremors in Manila.—A set of diagrams which clearly show the relationship between various atmospheric phenomena and the occurrence of tremors are the monthly sheets of the Meteorological Observatory in Manila, where from some date prior to 1883 observations have been made with Bertelli's tromometer. Tremor storms are apparently frequent from the end of June until the end of November, and accompany winds having a velocity of from 50 to 100 km. per hour, the barometer being low. During the remaining months of the year although slight tremors are frequent it is seldom that they are pronounced. When winds are fairly strong, reaching 30 or 40 km., unless these are continuous over several days the tremors are slight. Cases occur when tremors are fairly frequent with a low barometer (757 mm.) whilst there was but little wind. On the other hand, with a wind not exceeding 30 km., there have been decided tremors with a high barometer (763 mm.). The conclusion to be derived from these records, which, however, do not show the state of the barometric gradient, is that tremors are frequent with high winds, with winds of moderate intensity if these are continuous over several days, and at times when the barometer is low. Because they are sometimes absent when a wind of moderate intensity is blowing, it would seem that their appearance may be more closely connected with changes in barometrical pressure than with the mechanical effects of wind upon surface irregularities. They do not appear to be connected with daily changes in temperature, the hygrometric state of the atmosphere, or with the occurrence of earthquakes.

Since writing the above Father M. Saderra, S.J., Director of the Observatory at Manila, writes me as follows: 'Evidently the results are influenced by atmospheric currents, but in an indirect manner, as is proved by the fact that the hours of greatest wind force and greatest movements of the tromometer do not always coincide. The influence is verified by means of the vibratory motion which the wind produces in the earth itself by impinging against mountains. It now remains to observe and study this influence and endeavour to ascertain which wind exerts most influence. Hitherto this has not been feasible, but now, God helping, I will set about doing it.'

Although these observations throw a certain amount of new light upon the occurrence of tremors, and possibly explain their morning frequency, the causes producing tremor storms are yet obscure In Japan, at least, they appear to be a surface phenomenon which exhibits itself in different degrees in different localities. Although the longer period motions of horizontal pendulums show that changes in barometrical pressure may be sufficient to produce changes in level, it does not seem unlikely that rapid alterations in barometrical pressure over an area, the yielding of different portions of which are unequal, may be sufficient to create irregular mechanical disturbances in such a district, and the motion once started as with a severe earthquake may continue for several hours after the initiating cause has ceased. Whatever may be the cause of these ubiquitous phenomena, because they interfere with so many delicate physical operations, they certainly demand serious attention. For the assistance of those who desire to scrutinise the analyses of which I have only given the results or to make new investigations, the following list of meteorological conditions during the period which has been considered is here appended. (See Appendix, p. 182.)

(i) *Meteorological Tables for Tokio, October* 13, 1894, *to January* 1895.

The following tables have been extracted or computed from information given in the weather maps which are issued three times per day by the Central Meteorological Office in Tokio :—

1894	Barometer			Barometric Change	Barometric Gradient			Temperature			Rain			Weather			Relative Humidity						Vapour Tension						Force of Waves	
	6 a	2 p	10 p		6 a	2 p	10 p	6 a	2 p	10 p	6 a	2 p	10 p	6 a	2 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p	Joga-shima	Inu-boye
Oct. 13	70·4	67·9	65·8	+0·0	55	35	40	14·8	18·1	15·0	—	—	7	cl	cl	r	79	77	72	75	99	95	9·7	9·7	10·0	11·6	12·3	12·0	2·0	3·0
" 14	63·1	61·3	62·9	−6·6	50	100	100	14·3	18·2	16·5	13	7	—	r	r	cl	95	96	98	88	90	94	11·6	11·6	12·9	13·6	13·2	13·1	1·8	3·0
" 15	63·6	64·0	66·1	+2·7	60	60	40	14·6	19·6	16·4	—	—	2	cl	r	cl	98	95	85	80	91	92	12·8	11·7	12·4	13·5	13·7	12·7	1·0	2·2
" 16	65·4	63·3	64·1	−0·7	100	130	50	15·8	16·3	16·3	—	19	20	r	r	r	91	96	98	98	98	99	12·6	12·8	13·1	13·4	13·4	13·5	1·0	2·0
" 17	64·8	65·5	67·2	+2·2	50	60	60	15·9	18·4	16·1	8	—	—	cl	cl	cl	99	98	79	81	86	89	13·4	13·1	12·8	12·6	12·3	12·1	1·0	2·0
" 18	68·4	68·1	68·4	+2·6	50	50	50	15·0	19·3	14·4	—	—	—	cl	f	cl	87	91	64	55	74	84	11·6	11·6	9·7	9·1	9·9	10·2	1·0	2·0
" 19	66·7	64·5	56·1	−3·6	70	50	70	12·2	18·3	15·5	—	—	—	f	cl	r	88	87	59	66	75	87	9·4	9·2	9·7	10·3	10·3	11·3	1·3	2·0
" 20	64·2	63·2	61·9	−1·3	50	60	40	13·2	15·8	13·3	—	—	—	cl	cl	cl	94	95	83	71	83	83	11·0	10·7	10·1	9·4	10·0	9·5	1·7	2·0
" 21	60·4	59·3	61·1	−3·9	100	60	60	11·8	19·4	12·2	—	—	—	r	c	cl	82	92	77	45	69	92	9·3	9·5	9·3	7·6	8·2	9·7	1·8	1·7
" 22	61·5	60·7	63·4	+1·4	60	50	50	11·4	19·0	13·1	—	—	—	cl	cl	cl	92	93	62	52	73	67	10·1	9·3	8·6	8·4	9·6	7·5	1·3	2·0
" 23	63·6	63·3	64·8	+2·6	50	60	100	11·0	15.6	11·8	—	—	—	cl	cl	cl	83	76	62	61	78	84	8·2	7·4	7·2	8·0	9·0	8·6	2·0	3·0
" 24	65·2	64·5	67·6	+1·2	100	60	50	10·4	14·2	6·6	9	2	—	r	cl	c	92	99	96	75	93	94	9·2	9·2	9·5	9·0	9·1	8·0	1·2	2·0
" 25	69·7	69·4	69·9	+4·9	60	110	30	7·0	16·5	11·8	—	—	3	f	cl	r	92	98	69	59	72	92	7·5	7·3	8·7	8·2	8·5	9·5	1·0	2·0
" 26	64·3	59·1	60·6	−10·3	25	20	50	9·5	14·0	14·0	20	8	2	r	cl	r	96	98	100	89	99	99	8·7	8·7	9·4	10·5	11·4	11·7	1·8	2·5
" 27	60·5	60·2	61·6	+1·1	100	70	50	13·8	15·6	15·2	4	—	—	cl	cl	r	100	95	90	93	96	96	11·7	11·1	11·9	12·2	12·4	12·3	1·5	2·0
" 28	61·8	63·3	66·7	+3·1	60	70	50	13·9	20·1	14·1	—	—	—	cl	f	cl	99	95	63	58	80	73	12·0	11·2	9·9	10·1	10·6	8·7	1·0	1·7
" 29	68·1	66·9	67·9	+3·6	100	80	60	10·9	20·0	13·2	—	—	—	f	f	f	88	83	54	52	76	85	9·5	8·0	8·0	9·0	10·0	9·5	1·0	2·0
" 30	66·2	59·3	56·3	−7·6	18	25	40	12·6	12·7	12·6	—	21	22	r	r	c	85	82	93	97	97	97	9·0	8·9	9·5	10·6	10·3	10·6	1·5	2·0
" 31	57·9	57·2	56·7	−2·1	40	50	80	11·6	21·3	14·2	—	—	—	f	c	c	92	88	60	61	82	97	9·3	9·9	10·2	11·4	11·5	11·7	1·2	3·0
Nov. 1	57·9	58·3	66·3	+1·6	45	60	35	10·9	20·1	13·6	—	—	—	g	f	c	99	100	52	44	78	62	11·5	9·7	7·4	7·7	9·0	7·2	2·0	2·0
" 2	63·2	63·8	66·0	+5·0	40	50	50	10·6	16·3	11·2	—	—	—	cl	f	f	65	70	48	54	84	86	6·8	6·7	6·0	7·3	9·0	8·5	1·0	2·0
" 3	66·9	66·0	67·1	+2·2	40	60	60	7·3	19·0	12·9	—	—	—	c	cl	cl	92	89	60	52	76	86	7·7	6·8	7·7	8·4	8·7	9·5	1·0	2·0
" 4	64·5	58·9	56·0	−7·1	35	25	50	12·4	11·9	13·3	—	17	14	r	r	r	84	84	96	97	99	99	8·9	9·0	9·9	10·1	10·5	11·2	1·8	2·0
" 5	53·8	52·1	55·6	−6·8	30	40	35	12·6	21·3	12·8	2	—	—	cl	c	c	100	99	67	54	76	67	11·4	10·7	12·3	10·3	9·4	7·4	2·2	2·0
" 6	59·6	60·0	64·9	+7·9	50	150	150	11·2	19·0	7·7	—	—	—	c	c	c	66	54	43	32	56	85	6·4	5·4	6·0	5·3	6·1	6·6	1·3	1·2
" 7	66·2	64·3	65·4	+4·1	100	100	—	6·0	17·8	10·5	—	—	—	c	c	c	80	78	57	52	82	82	6·0	5·4	6·5	7·8	9·6	7·8	1·0	1·0
" 8	64·9	62·9	62·8	−1·4	—	100	—	7·4	18·0	10·6	—	—	—	cl	f	cl	92	84	63	54	90	96	7·4	6·5	7·5	8·7	9·5	9·1	1·0	1·2
" 9	60·1	57·1	57·7	−5·8	—	60	50	8·0	20·9	12·0	—	—	—	c	c	f	96	98	63	55	89	97	8·9	7·9	8·7	10·1	11·3	10·1	1·5	1·0
" 10	57·2	56·9	60·9	−0·2	50	50	50	11·3	19·1	9·0	—	—	—	f	c	c	86	78	53	46	47	69	7·8	7·7	7·1	7·6	5·4	5·9	1·3	1·7
" 11	61·5	60·8	60·6	+3·9	—	60	50	6·4	15·6	11·4	—	—	—	cl	cl	cl	75	81	61	62	81	86	5·9	5·8	6·2	8·2	9·1	8·7	1·7	1·7
" 12	58·2	55·2	56·2	−5·6	50	50	40	9·1	10·1	9·0	4	14	3	r	r	cl	76	94	94	96	96	98	7·1	8·1	8·5	8·8	8·6	8·4	2·0	2·3
" 13	57·2	56·0	53·9	+0·8	60	50	30	6·3	16·3	8·6	—	—	—	c	c	c	98	92	55	52	84	55	7·5	6·5	6·4	7·1	9·2	4·6	1·8	2·3
" 14	62·7	62·7	65·8	+6·7	40	35	40	8·6	3·4	8·4	—	—	—	c	c	c	63	78	37	51	76	68	4·5	4·6	4·6	7·0	7·4	5·6	1·3	1·3
" 15	69·2	68·7	69·7	+6·0	100	50	50	4·6	17·5	7·5	—	—	—	c	c	c	82	88	58	44	81	92	5·6	5·6	6·0	6·4	7·3	7·1	1·0	1·2
" 16	68·8	64·9	63·3	−3·3	55	55	50	5·0	17·9	8·0	—	—	—	c	f	c	91	86	57	51	90	85	6·4	5·6	6·9	7·8	8·8	7·2	1·3	1·0
" 17	63·5	64·6	68·6	+0·6	23	10or50	50	9·2	12·7	9·2	—	—	—	c	c	c	92	69	43	41	48	42	6·7	5·9	5·0	4·4	4·0	3·7	1·3	1·8
" 18	70·7	69·7	71·3	+4·2	60	50	—	3·0	14·0	5·2	—	—	—	c	c	c	53	75	49	47	86	93	4·0	4·2	4·7	5·6	6·4	6·1	1·0	1·0
" 19	71·1	70·0	70·3	−0·3	—	60	40	7·0	18·8	8·2	—	—	—	cl	c	f	93	86	61	52	79	91	5·5	5·3	5·5	7·1	7·4	7·4	1·0	1·0
" 20	68·8	64·2	60·6	−5·2	40	15	35	6·5	10·2	9·6	—	1	10	cl	r	r	90	86	85	97	100	100	6·7	6·2	7·1	9·1	8·9	8·9	2·0	1·2

1894	Barometer			Barometric Change	Barometric Gradient			Temperature			Rain			Weather			Relative Humidity						Vapour Tension						Force of Waves	
	6 a	2 p	10 p		6 a	2 p	10 p	6 p	2 p	10 p	6 a	2 p	10 p	6 a	2 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p	Joga-shima	Inu-boye
Nov. 21	64·7	66·6	71·0	+2·4	50	80	—	7·1	20·1	10·0	—	—	—	f	c	c	98	100	70	45	77	93	8·2	7·5	10·2	7·9	9·1	8·5	1·8	3·0
" 22	71·3	67·2	66·2	+0·6	100	100	100	7·2	17·5	9·6	—	—	—	f	c	c	94	97	64	58	89	98	7·9	7·4	8·3	8·6	9·2	8·8	1·2	1·7
" 23	63·1	64·1	68·9	−3·1	50	30	45	8·6	17·0	13·5	—	—	—	cl	c	cl	97	95	75	64	83	64	7·8	7·9	8·9	9·2	10·1	7·4	1·3	3·0
" 24	71·4	71·7	73·7	+7·6	40	40	50	9·0	12·4	9·5	—	—	1	cl	cl	r	70	78	69	72	93	98	6·8	6·7	6·7	7·7	8·3	8·7	1·0	2·3
" 25	72·0	69·8	70·9	−2·2	150	50	75	9·7	10·9	11·0	3	15	1	r	r	cl	100	100	100	93	97	94	8·6	8·5	8·9	9·1	9·5	9·2	1·0	2·0
" 26	70·1	67·9	69·3	−1·6	30	60	50	10·4	15·8	11·7	—	—	—	cl	f	c	97	97	82	78	92	96	9·4	9·1	9·4	10·4	10·4	9·8	1·0	2·0
" 27	69·9	69·6	70·5	+1·7	70	60	35	6·7	16·3	12·3	—	—	—	fg	f	cl	100	100	74	64	80	81	8·7	7·3	8·8	8·8	8·9	8·6	1·0	2·0
" 28	65·8	61·4	59·1	−8·2	35	30	60	9·8	13·8	17·7	1	—	—	r	cl	c	93	80	88	82	94	77	9·1	7·2	9·2	9·7	9·4	11·6	1·8	1·3
" 29	58·2	58·4	56·3	−3·2	30	35	28	7·7	21·4	12·6	—	—	22	f	cl	cl	98	98	51	40	88	88	8·5	7·7	8·6	7·5	4·6	9·2	2·7	1·0
" 30	57·9	57·2	66·6	+4·1	35	35	30	11·6	21·3	7·1	—	—	—	r	cl	—	72	96	92	49	56	59	7·4	8·4	7·2	5·6	4·8	4·4	1·3	2·3
Dec. 1	68·4	68·4	70·0	+6·1	40	40	80	6·1	9·2	6·8	—	—	—	c	cl	cl	54	52	48	46	67	70	3·9	3·6	3·9	3·9	5·2	5·1	1·0	1·0
" 2	68·7	64·4	60·9	−4·0	50	40	—	3·2	3·2	4·0	—	6	2	cl	r	cl	69	77	78	96	98	96	4·6	4·4	4·7	5·5	5·8	5·8	1·0	1·7
" 3	59·0	58·5	61·8	−5·9	60	50	30	4·0	3·1	8·8	—	—	—	c	f	c	96	100	67	41	53	54	6·1	5·7	6·9	5·5	5·2	4·6	1·5	1·5
" 4	63·3	62·7	64·2	+4·2	40	60	35	6·2	11·6	5·4	—	—	—	c	c	cl	54	52	44	40	70	68	4·1	3·7	3·6	4·1	5·2	4·5	1·2	1·0
" 5	64·4	63·5	66·5	+0·8	40	30	25	4·0	10·4	4·2	—	—	—	c	c	c	64	72	46	42	48	54	4·4	4·4	3·9	3·9	3·3	3·3	1·0	1·4
" 6	66·8	66·5	68·3	+3·0	60	45	35	3·8	9·0	3·6	—	—	—	f	c	cl	56	51	49	47	69	71	3·4	3·0	3·7	4·0	4·4	4·4	1·0	1·0
" 7	69·5	69·7	72·7	+3·2	40	50	40	0·4	10·5	2·2	—	7	39	c	c	c	72	77	44	37	69	71	4·2	3·6	3·5	3·5	4·4	3·7	1·0	1·6
" 8	73·2	71·7	72·1	+2·0	30	35	40	98·8	9·3	4·6	52	4	—	c	cl	cl	83	78	60	55	65	75	3·8	3·2	3·8	4·8	4·9	4·7	1·0	1·0
" 9	69·7	67·3	68·0	−4·4	30	35	28	1·6	8·8	8·4	—	—	—	cl	cl	cl	77	81	67	57	63	74	4·2	4·1	4·4	4·8	5·6	6·0	1·7	2·2
" 10	64·9	59·0	49·2	−8·3	15	14	12	5·6	5·5	8·8	—	—	—	r	r	r	79	81	95	98	100	100	5·5	5·4	6·3	6·6	7·3	8·4	3·0	3·0
" 11	38·3	41·1	47·3	−17·9	8	14	24	10·9	17·3	10·0	—	—	—	r	f	c	100	96	96	53	65	81	9·6	9·3	9·0	7·8	7·5	7·4	3·7	3·0
" 12	50·7	53·1	58·5	+12·0	25	20	35	7·4	15·5	8·4	—	—	—	c	c	cl	90	73	42	37	54	59	6·5	5·6	5·1	4·9	4·9	4·9	1·7	2·3
" 13	62·6	63·9	64·4	+10·8	40	40	80	6·4	14·0	9·8	—	—	—	c	c	cl	56	54	38	41	78	70	4·1	3·9	4·0	4·8	6·0	6·3	1·2	1·7
" 14	60·5	54·9	53·8	−8·1	40	50	20	4·2	16·6	7·0	—	—	—	cl	f	c	86	89	74	42	60	75	5·7	5·5	5·3	5·8	6·8	5·6	2·7	2·0
" 15	57·4	60·0	66·9	+5·1	15	10	35	4·4	3·2	99·4	4	—	—	cl	cl	c	31	91	92	68	41	59	6·2	5·7	4·9	3·9	2·0	2·6	2·0	2·0
" 16	71·0	71·1	71·7	+11·1	40	60	100	95·6	4·1	98·7	—	—	—	c	cl	cl	48	88	35	45	56	78	1·8	2·9	1·9	2·8	2·7	3·2	1·0	2·0
" 17	65·1	57·6	54·6	−13·5	25	50	20	99·2	6·1	2·0	—	—	—	cl	f	c	70	69	57	56	89	92	2·9	3·0	2·8	4·0	5·5	4·9	1·7	1·0
" 18	54·9	57·6	63·3	—	32	30	40	99·0	7·6	0·9	—	—	—	c	c	c	90	85	46	31	33	47	3·9	3·6	3·1	2·4	1·9	2·3	2·2	1·0
" 19	64·5	63·6	64·8	+6·0	38	60	60	95·9	8·8	0·2	—	—	—	c	c	c	74	75	26	39	77	77	2·8	2·5	1·6	3·3	4·0	3·5	1·5	1·0
" 20	64·9	63·9	66·2	+0·3	60	35	50	97·8	10·3	2·1	—	—	—	c	c	c	94	82	40	43	67	68	3·2	3·2	3·0	4·1	4·1	3·6	1·5	1·0
" 21	67·5	66·6	68·6	+2·7	50	50	38	98·4	11·4	4·0	—	—	—	c	c	c	65	75	39	34	76	56	3·2	3·1	3·1	3·4	4·6	2·4	1·0	1·0
" 22	67·8	64·5	66·1	−2·1	45	35	40	99·2	12·2	3·0	—	—	—	c	c	c	60	74	45	37	59	75	3·3	3·2	4·0	3·9	4·7	4·2	1·0	1·0
" 23	66·7	66·0	65·8	+1·5	40	70	100	4·6	12·7	5·8	—	—	—	c	f	cl	81	62	45	33	62	60	3·8	3·9	4·1	3·5	4·8	4·1	1·0	1·0
" 24	61·2	58·4	60·9	−7·6	90	25	45	1·8	13·1	5·9	—	—	—	cl	c	cl	57	70	49	36	50	60	3·4	3·6	3·8	4·0	3·9	4·1	1·2	1·0
" 25	62·4	63·1	67·1	+4·7	60	45	60	2·5	10·9	2·6	—	—	—	c	c	c	67	69	47	41	70	69	4·3	3·8	3·8	3·9	4·3	3·8	1·0	1·7
" 26	69·0	67·9	69·2	+4·8	60	50	25	0·1	11·9	2·0	—	—	—	c	c	c	62	66	54	43	78	81	3·1	3·0	3·6	4·5	4·9	4·5	1·2	1·0
" 27	66·2	59·7	53·4	−8·2	25	20	25	98·2	16·5	14·0	—	—	—	c	c	c	93	97	57	45	64	67	4·2	3·9	5·7	7·3	7·5	8·0	2·2	1·7
" 28	46·8	48·7	54·4	−11·0	25	20	30	9·2	10·0	2·0	3	—	—	f	c	c	89	71	39	33	39	40	4·5	6·1	3·9	3·0	2·5	2·1	3·0	2·0
" 29	54·6	53·9	57·8	+5·2	30	20	30	97·0	11·1	3·1	—	—	—	c	c	c	52	79	55	40	37	50	2·4	2·9	3·7	4·0	2·8	2·9	1·8	1·5
" 30	59·0	58·4	63·0	+4·5	30	30	—	1·9	9·6	1·2	—	—	—	c	c	c	42	42	37	29	39	55	2·3	2·2	2·8	2·7	2·7	2·8	1·5	1·3
" 31	62·6	59·3	57·6	+0·9	—	—	—	0·0	11·1	2·0	—	—	—	c	c	c	55	44	32	35	66	70	2·6	2·0	2·6	3·4	4·1	3·7	1·3	1·0

1895	Barometer			Barometric Change	Barometric Gradient			Temperature			Rain			Weather			Relative Humidity						Vapour Tension					
	6 a	2 p	10 p		6 a	2 p	10 p	6 a	2 p	10 p	6 a	2 p	10 p	6 a	2 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p	2 a	6 a	10 a	2 p	6 p	10 p
Jan. 1	57·2	57·8	60·3	−1·5	25	30	50	99·2	10·0	1·8	—	—	—	c	c	c	72	67	46	38	53	66	3·2	2·9	3·4	3·5	3·5	3·4
„ 2	60·7	58·8	57·3	+1·0	100	40	70	99·6	6·2	1·8	—	—	—	f	cl	c	61	72	56	63	93	96	3·0	3·2	3·4	4·5	5·3	5·0
„ 3	55·4	53·1	55·1	−5·7	40	25	25	98·2	10·5	5·1	—	—	—	c	c	c	94	97	78	60	76	49	4·4	3·9	5·0	5·7	5·7	3·2
„ 4	55·8	44·8	59·5	+1·7	50	17	28	1·8	5·4	93·7	—	—	—	f	f	c	59	54	50	46	60	85	3·2	2·8	2·8	3·1	3·1	3·5
„ 5	61·7	61·1	60·7	+6·3	70	75	80	96·8	5·9	97·4	—	—	—	c	c	c	70	64	40	33	56	87	2·8	2·3	2·1	2·3	2·6	3·3
„ 6	60·6	61·3	65·5	+0·2	50	60	60	95·4	7·1	99·4	—	—	—	c	c	f	80	74	43	34	33	59	2·8	2·4	2·4	2·5	1·9	2·6
„ 7	66·5	66·3	68·6	+5·0	40	60	100	98·0	7·7	98·2	—	—	—	c	c	c	52	75	42	51	60	90	2·3	3·0	2·3	3·2	3·6	3·6
„ 8	68·9	67·5	62·4	+1·2	30	100	70	98·2	9·8	0·6	—	—	—	c	c	c	75	80	41	47	74	82	2·8	3·2	2·3	4·2	4·2	3·9
„ 9	67·8	64·9	62·3	−2·6	70	40	60	97·6	2·2	3·4	—	1	—	c	r	cl	78	69	68	90	89	89	3·3	3·4	3·3	4·8	5·0	5·2
„ 10	60·8	61·4	63·0	−3·5	35	15	30	2·4	7·0	5·8	—	—	—	cl	cl	cl	92	90	79	67	80	82	5·1	4·9	5·1	5·0	5·9	5·6
„ 11	60·9	59·8	59·6	−2·4	40	45	45	2·6	3·7	3·4	2	3	—	r	r	cl	86	92	94	94	94	91	5·5	5·1	5·2	5·6	5·6	5·3
„ 12	57·5	53·2	52·8	−5·8	50	50	35	3·5	6·1	1·4	—	—	—	cl	cl	f	94	93	91	87	95	98	5·3	5·4	5·9	6·1	5·7	5·7
„ 13	53·2	56·5	61·2	+3·3	30	35	35	99·8	6·3	98·6	—	—	—	c	cl	c	98	95	26	27	43	55	4·8	4·3	1·8	1·9	2·1	2·3
„ 14	64·4	64·6	66·4	+8·1	35	50	70	97·6	3·8	98·6	—	—	—	c	cl	cl	56	60	50	23	49	66	2·1	2·3	2·2	1·4	2·2	2·7
„ 15	67·1	65·4	65·3	+0·8	90	70	100	95·4	6·2	93·2	—	—	—	f	c	c	57	73	58	42	63	67	2·3	2·5	2·7	3·0	3·1	2·9
„ 16	65·2	63·1	63·5	−2·3	100	100	70	96·0	5·9	93·6	—	—	—	f	c	c	70	78	65	48	69	85	2·7	2·7	2·9	3·6	3·4	3·5
„ 17	62·9	59·7	56·1	−3·4	70	100	50	98·2	5·8	0·5	—	—	5	cl	cl	s	82	77	52	53	64	98	3·3	3·1	2·7	3·6	4·0	4·6
„ 18	51·8	52·2	58·1	−7·5	30	35	40	1·6	0·2	93·4	5	1	1	cl	s	c	96	92	68	92	98	48	4·6	4·7	5·2	4·9	4·5	2·1
„ 19	60·8	59·4	59·8	+7·2	60	50	30	97·2	5·1	98·6	—	—	—	c	c	c	40	69	36	36	58	76	1·8	2·2	1·9	2·4	3·0	3·1
„ 20	60·8	61·0	60·7	+1·6	60	70	60	95·5	4·9	93·1	—	—	—	c	c	c	78	80	52	52	68	74	2·7	2·6	2·5	3·6	3·1	3·1
„ 21	61·8	61·6	66·2	+0·6	65	45	50	98·8	5·8	99·2	—	—	—	c	cl	c	51	45	26	39	44	58	2·3	1·9	1·7	2·7	2·2	2·5
„ 22	68·2	67·9	69·1	+6·3	70	90	90	97·7	5·4	1·7	—	—	—	c	c	cl	60	54	36	33	47	71	2·4	2·1	2·0	2·2	2·5	3·7
„ 23	66·9	62·6	62·4	−5·3	60	65	60	97·1	8·4	4·3	—	—	—	c	f	c	76	76	46	49	43	54	3·1	2·8	2·9	4·0	3·4	3·4
„ 24	63·6	60·6	58·0	−2·0	45	40	30	1·4	9·0	4·0	—	—	—	c	c	c	64	56	47	43	52	58	2·9	2·8	3·2	3·7	3·9	3·5
„ 25	58·2	62·7	68·3	+2·1	25	40	55	97·8	8·7	98·6	—	—	—	c	c	c	97	87	39	30	43	62	4·1	3·4	2·4	2·1	2·1	2·5
„ 26	70·5	69·0	68·4	+5·3	90	100	30	95·7	4·9	1·8	—	—	—	c	c	cl	62	78	51	38	43	51	2·3	2·6	2·4	2·4	2·1	2·6
„ 27	64·7	56·1	51·2	−12·9	25	30	45	99·2	7·0	2·8	—	—	24	c	cl	cl	77	76	47	64	94	94	3·4	3·3	2·5	4·8	7·8	5·3
„ 28	55·0	57·1	62·1	+1·0	25	25	25	0·0	11·2	0·	—	—	—	c	f	c	90	98	75	31	30	62	5·2	4·4	5·8	3·0	2·5	2·8
„ 39	62·4	61·5	59·5	+4·4	55	70	30	99·4	7·7	2·8	—	—	—	c	f	c	45	67	41	49	46	61	2·4	2·9	2·1	3·8	3·2	3·9
„ 30	60·0	60·1	—	−1·4	20	30	—	93·6	6·4	—	—	—	—	c	c	—	48	73	34	26	21	45	2·5	3·0	2·2	1·8	1·1	1·9
„ 31	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	54	58	23	36	55	70	2·0	2·0	1·8	2·9	3·1	3·4

The barometer readings are given as the number of millimetres above 700.

The barometrical change is the difference in the readings on successive days taken at 2 P.M.

The numbers representing barometric gradient are the number of millimetres on the weather map (where 1 mm.=6 geo. miles), which correspond to a difference in pressure of 5 mm. Where a number is omitted it means that the barometrical pressure has been fairly uniform over Central Japan.

Temperature is indicated in the Centigrade scale and rain in millimetres.

To show the state of the weather the following signs have been used—*cl*=cloudy, *c*=clear, *r*=rain, *f*=fine, *fg*=fog, and *s*=snow.

The relative humidity is in percentages, 100 being saturation.

Tension is expressed in millimetres of mercury.

The force of waves is recorded at 2, 6, and 10 A.M., and at 2, 6, and 10 P.M. at the various lighthouses round the coast. The scale employed is as follows :—0=calm, 1=smooth, 2=moderate, 3=rough, 4=high, 5=very high, 6=tremendous. In the tables the mean value for the above hours is given for Jogashima, 33 miles south from Tokio, and for Inuboye, 53 miles east of Tokio.

(*j*) *Earthquakes recorded by Horizontal Pendulums in Tokio, October* 31, 1894, *to February* 7, 1895.

To obtain Greenwich mean time, subtract nine hours. The instrument which recorded a given shock is indicated by its letter. The numbers in brackets indicate the width in millimetres of the displacement as shown upon the photographic trace. The times given are obtained by a *rough* measurement of the diagrams. For several of these disturbances it would have been desirable to have made the time observations more accurate, but owing to the loss of my notebooks by fire, this is now impossible.

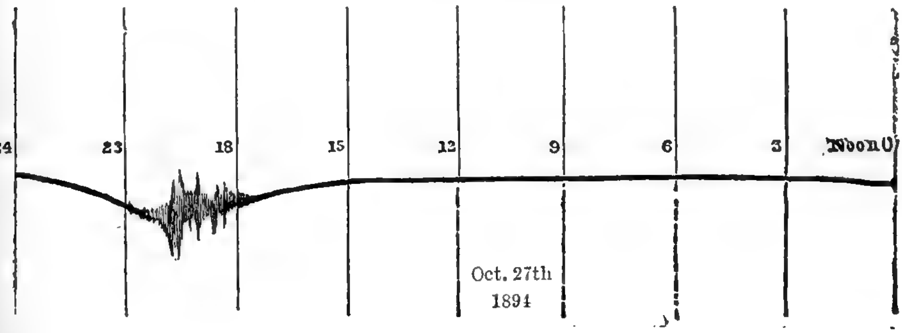
1894		
Oct. 13	8.59 (5), A.	Sudden commencement.
	21.27. J.	
15	7.0 (2), A.	Sudden commencement.
	7.30 (2) ,,	,, ,,
	9.45 (6) ,,	,, ,,
18	1.20 (6) ,,	Gradual ,,
19	9.0 (2) ,,	
	4.33 (2), J.	
	7.38 (1) ,,	
	10.7 (1) ,,	
26	9.0, K.	Three slight disturbances.
27	2.10 (10), A.	
	18.0 (10), A.	Commenced gently; duration 1 hr. 45 min.
	18.5. J.	,, ,, ,, 3 hrs. 0 min.
	17.41[1] K.	,, ,, ,, 2 hrs. 25 min.
28	4.20 (3), A.	
29	11.0 (6), ,,	
31	8.0 ,,	Slight.
	9.30 ,,	,,
	10.0 (5), ,,	

[1] Time evidently wrong.

Nov. 2	1.30. J. Commenced gently, duration 30 min.
	16.30. J. " " " 1 hr. 30 min. Three shocks.
4	20.0 (10), A. Commenced gently.
	21.0. J. Slight.
5	5.30 to 6.30. A. Two shocks of (3) and (8.)
	7.00 ? A. Slight.
	10.0 ? " "
8	4.0 " "
	7.30 " "
	9.0 ? " "
13	4.30 ? (10), A.
21	0.0 to 9. A. About seven disturbances.
22	2.0. A. Slight.
	7.0. " "
23	3.0 (10), K.
27	12.0 (10), N.
28	4.0 (10), A.
	5.0 (5), A. Commenced gently, duration 3 hrs.
29	2.0 to 2.30 (10), A.
	4.0 to 7.0 (5) "
	10 0 (5) "
30	9.0, about J. Strong. Local origin.
	12.0. J.
Dec. 8	6.0. A.
	7.45 (4), "
11	20.0 "
	22.0 to 24.0. A. Several small disturbances.
19	1.0, 3.0, 4.30 to 6.0, 7.0 and 8.0, each about (5). A.
20	2.0, several; 2.45, 4.0, 4.30 and 9.0, each (2) to (4). A.
21	1.0. 2.0, 4.0 and 5.0. A. All doubtful.
23	3.0 (15). local origin; and up to 9.0, four shocks each (2). A.
30	18.0 (20).
	19.0 (5).
1895	
Jan. 2	9.0 and 11.0 (3) or (4) ? A.
3	2.0 to 3.0 (5) ? A.
5	3.0 and 6.30 "
	6.15 and 7.15 (5). J.
8	7.30 (2). A.
9	9.0 and 11.0 (1). A.
10	3.15 and 4.0 (1). " (local origin).
11	7.0 and 9.0, and 23.45 (1). A.
14	3.0 to 5.0. A. May be tremors.
15	2.0 and 7.30 (5). A.
	3.0 and 7.0 (27).
16	9.30 (2). A.
17	5.0 (5). "
	21.0 (4). Earthquake. A.
	21.0 (2).
18	3.0 and 6.0 (3), introduction to a tremor storm. (Local origin.)
	11.0, large earthquake. A. (Local origin.)
	11.0.
19	3.0 and 4.30 (2). A. Local origin.
21	9.0. A. Slight. Local origin.
27	7.30, 10.0 and 11.0. Slight. A.
23	7.0. A.
27	6.0 to 8.0. O. Perhaps tremors or three quakes.
28	9 0 (1). A.
29	8.0 (1). A.
Feb. 4	10.0. A.
5	10.0. A.
6	1.30 and 8.30 A.
7	8.0. A.

One of the most interesting of these disturbances is that which was recorded at three stations, at about 18 hours, on October 27. The origin of this was near to the Antipodes of Japan, in the Argentine Republic. In the shaken district Dr. E. von Rebeur-Paschwitz tells me that the mean velocity of progagation was about 1·2 km. per sec. Mr. C. Davison tells me that it reached Europe to be recorded at Rome with a mean velocity for the large motion, of 3·17 km. per sec., the preliminary vibrations having a velocity of 10·38 km. per. sec. These latter movements reached Charkow and Nicolaiew with velocities of 11·47 and 9·47 km. per sec. If the record J for Japan can be assumed to be approximately correct, then the movements recorded in Japan, if they were propagated over the surface of the earth, reached that country with a mean velocity of 19 km. per sec.[1] The figure is reduced from the record of K.

FIG. 14.



III.—Description of a Catalogue of 8,331 Earthquakes recorded in Japan between January 1885 and December 1892.

(a) *History of the Catalogues.*

In order to determine the number of shocks which are felt per year in Japan, and to obtain some general idea as to their distribution, in 1880, with the assistance of Mr. Toshiwo Nakano, the present writer communicated with residents in all the principal towns of the Empire, asking them to furnish information about the seismic activity, both past and present, of the districts in which they resided. An examination of the replies which were received led to the conclusion that on the average there were three or four shocks per day, or for Japan alone there were as many shocks per year as Professor Heim had calculated for the whole globe ('Trans. Seis. Society,' vol. iv. p. 30). In the following year, in order to determine the extent of country which was shaken by a given shock, bundles of postcards were sent to very many towns and villages within a range of about 100 miles of Tokio, with a request that every week one of these cards should be returned with a statement of the earthquakes which had been felt. The result of these communications showed that nearly all the shakings which disturbed Tokio came from the east and north, and seldom passed beyond the mountain ranges to the west and south. These facts having been established, the barricade of postcards was extended northwards until it reached Sapporo, which is about 450 miles north from Tokio. With this system, between October 1881 and October 1883, 387 earthquakes were recorded, for each of which a map was drawn showing

[1] They may have passed through the earth with a velocity of 13 km. per second.

the area which had been shaken and the approximate centre from which each disturbance had originated. To render the observations more complete, one or two watches were given to telegraph operators (a few of the more enthusiastic observers provided themselves with good time-keepers), and seismographs were sent to the following stations :—

	Geo. Mile.	From Tokio.
Nagasaki	550	W.S.W.
Kobe	240	W. by S.
Yokokama	15	S.W. by S.
Chiba	17	E. by S.
Kisaradzu	15	S.E. by S.
Kamaishi	120	N.N.E.
Hakodate	375	N. by E.
Sapporo	450	N. by E.

From these observations it was definitely shown that the greater number of earthquakes had their origin along the seaboard or beneath the ocean, that the volcanic and mountainous regions of Japan are singularly free from shakings, and that the country might be divided into seismic regions ('Trans. Seis. Soc.,' vol. vii. Part II.). The establishment of these and other important results in 1884 led the Imperial Meteorological Department, then under the direction of Mr. Arai Ikunosuke, to undertake the continuation and extension of investigations, the labour and expense attending which were altogether too great to be borne by an individual. On the retirement of Mr. Arai the work was continued by Mr. K. Kobayashi, the present Director of the Bureau, and it is to his kindness that I am indebted for access to the vast amount of material that has been accumulated. The observing stations from which this material is being derived, and which for the last two years has been pouring in at a rate too fast for analysis, are as follows :—

Gunyakusho (district offices). (As several of the smaller of these are controlled by their larger neighbours, postcards and letters are only forwarded from 527)	804
Kencho (offices at the capitals of provinces)	43
Fu (large cities), Tokio, Kyoto, and Osaka	3
Light-houses	63
Light-ships	3
Meteorological Observatories (of these 39 have instruments)	52
Total number of reporting stations	968

The information derived from these stations, which are distributed over the Empire, an area of 140,000 square miles, is from time to time supplemented by records obtained from stations under the control of the Imperial University and those of private observers.

When an earthquake is felt, according to the area over which it has extended, the number of postcards, letters, and diagrams which may be received at the central station vary between three or four and several hundreds. From the catalogue it will be seen that between 1885 and 1892 more than 8,331 shocks have been recorded, and for each of these a separate map has been drawn. To draw these maps, which has been entirely the work of the Meteorological Department, it is possible that 80,000 to 100,000 documents were examined. For reducing this bulky mass of matter into the comparatively small and accessible form in which it has been published, my thanks are due to Mr. M. Suzuki, a former assistant of the Meteorological Bureau, who has worked with me, pointing out doubtful information, translating papers, calculating areas, determining centres, filling in maps, and in carrying out other tedious operations for the last twelve months.

The chief reason for terminating the catalogues at the end of 1892 is because the material subsequent to that date has not yet been reduced to the map form, and to examine all the documents necessary to accomplish this would have occupied at least another year ; also it may be added that what has been done is in all probability sufficient to determine whether work of this description is likely to lead to results of sufficient importance to guarantee its continuance.

(b) *Explanation of the Catalogues.*

In the first catalogue the shocks are placed in chronological order from 1 to 8,331. When disturbances have apparently been simultaneous in two distant localities, they are included under a single number.

In the second and third columns the date and time for each disturbance are given. When the latter is noted to seconds, the record refers to the commencement of motion at an observatory, like that in Tokio, which is provided with automatic chronographs. Until the end of 1887, these records, which are practically correct, refer to Tokio mean time, or 9 hr. 19 min. 1 sec. before Greenwich mean time. Subsequently to this date the times given are those of Long. 135° E., or nine hours before Greenwich mean time. The other time records are only approximately correct, and cannot be used in any investigation relating to the velocity with which earthquake motion is propagated.

The fourth column gives in square *ri* (1 square *ri*=5·96 square miles) the *land area* which was shaken. For small shocks which were only felt at one or two stations the determination of this quantity has largely depended upon the judgment of the observer. The figures given are those obtained from the maps by means of a planimeter and entered in the records of the Meteorological Department. In the second catalogue, based upon a second inspection of the maps, it will be noticed that many material alterations have been made in these quantities. In many instances the *land areas* of the first catalogue are *total areas*, but in others they only represent an insignificant portion of a disturbed tract, the centre of which was beneath the bed of the ocean. The limits of the areas given are those places round an origin up to which the movement was perceptible to people or sufficiently strong to have been recorded by ordinary seismographs. With instruments like delicately adjusted horizontal pendulums, there is no doubt that movements might have been detected far beyond these arbitrary limits. For example, shock number 4,145 has assigned to it a land area of 15,750 sq. *ri*, when we have good reasons for believing that with suitable instruments it might have been noted at any point upon the surface of our globe.

The number in the fifth column approximately indicates, as shown upon the key map, the epicentre of a disturbance, or a number on the coast line nearest to a submarine origin. In the second catalogue, the position of a submarine origin, by means of a distance in tens of miles and the direction in which it is to be measured from a central number, is defined more closely. On the key map the numbers referring to squares, each 10 miles by 10 miles, commence at the top and run from left to right down to the bottom of the same.

A line drawn on the key map through the numbers in the sixth column gives the boundary of the land surface which was shaken. The area of this should be equal to the quantity in the second column. By completing, when it may be necessary, this outline seawards, a *total area* is obtained, which is indicated by its major and minor axes in the second catalogue.[1]

In the small map, which is a photographic reproduction of a map the same size as the key map, the small dots indicate the position of all the epicentral numbers, and the large numerals ranging from 1 to 15, districts in which earthquakes are frequent. Districts 6 and 7 are bounded by straight lines because there was not sufficient space in which to place all the dots. For example, in District 7 all the dots indicate earthquakes which originated about the centre of this district. Until October 28, 1891, the disturbances in this district were not more numerous than they are in District 8.

When an earthquake has been felt at the extremities of the Empire, and at the same time not along a great length of coast line, as in Districts 1 and 10, it is often difficult to determine the direction or distance from the coast line of its origin. In these cases the assumption made has been that the shocks just reaching the coast have originated from about the same locality as the larger shocks which have spread some distance along the shore line, these stronger disturbances being severe at places just reached by their feebler successors. The signs + and – along the coast line indicate that near these places there are evidences of secular elevation or depression. This information was obtained by the help of Professor D. Kikuchi, who kindly assisted in the distribution of a circular to various towns and villages round the coast of the Empire inquiring whether from maps, traditions, or observations there were reasons to believe that changes had taken place in the relative position of the land and water. The large black dots on the map indicate the positions of more or less active volanic cones, in the neighbourhood of which there are huge bosses of volcanic rocks and many ancient craters. The dotted lines show the boundaries of provinces, which are usually the ridges of high mountains dividing one seismic region from another.

If analyses of this catalogue show that it is of any value, it is clear that several advantageous changes may be made in a system for its continuation. As it stands it is only a tentative effort to provide investigators with a new kind of data, which may lead to investigations not hitherto possible. None of the facts, excepting a few of the time observations, claim any great degree of accuracy. The object of the list drawn up for me by Dr. E. von Rebeur-Paschwitz is explained in the next section.

The long list of corrections, additions, and suggestions at the end of the volume, inasmuch as they have, so far as possible, been inserted in the second catalogue, almost entirely refers to the first catalogue. Although they show that actual errors occur in work of this description, they also show that from given data different persons may arrive at different results.

[1] The unit is 10 geographical miles.

(c) *Object of the Catalogues.*

The principal object of the catalogues, as we have indicated, is to furnish investigators with a certain quantity of material relating to the occurrence of earthquakes, different from that which has hitherto been at their disposal, on account of the want of which it has been impossible to make many desirable inquiries.

Many catalogues exist, like those of Perrey, Mallet, Kluge, de Ballore, and Fuchs, in which the actual number of records are equal to, or greater than, the number of earthquakes now noted, and which are equally good as foundations for a particular class of investigations. The incompleteness of these catalogues, however, is seen in the fact that they give for the whole world a frequency less than the present list gives for a small portion of it like Japan. If, for example, we take Dr. C. W. C. Fuchs' 'Statistik der Erdbeben,' 1865 to 1885, giving a list of some 8,000 disturbances, out of these Japan is credited with from three to thirty shocks per year, while a truer estimate would have been from 500 to 1,000. Again, it is often difficult to distinguish between shocks which have shaken a few square miles and those which have disturbed an empire. Large shocks and small shocks, primary shocks and after shocks, are with difficulty separable, and no data have been available enabling an investigator to separate disturbances arising from the yielding of strata in one area from those due to fracturing which might take place in a neighbouring region. Even when the lists of a particular observatory have been examined by themselves, inasmuch as its records are those of shocks of local orgin combined with those of shakings which originated at distances of several hundreds of miles, all that we can expect to find is a relationship between earthquake occurrence and influences of a widespread character. Such investigations have been made for the records of observatories, countries, and the world, with the result that a more or less pronounced annual and semi-annual periodicity and traces of what is apparently a lunar influence have been discovered.

No doubt many and very just objections may be made as to the accuracy of much of the material in the present list; but because it enables us to give approximate *weights* to the different shocks, to distinguish between primary and secondary disturbances, and to divide the country to which it refers into distinct seismic or natural districts, it is to be hoped that it will open the way for investigations along new lines.

Although the catalogues suggest several investigations hitherto impossible, inasmuch as it so often happens that one inquiry becomes the parent of another, it is impossible to indicate all the paths which may be followed. A suggestion given by the list, which shows that shocks originating in Japan have travelled to Europe, is that a ring of twelve or twenty-four stations situated round our globe would in a very short time give us valuable information, not simply about its crust, but possibly also about its interior.

One set of investigations which may possibly lead to interesting results will be those relating to the frequency and periodicity of earthquake shocks which may be considered as having equal values, or receive values relative to the area they have disturbed. Each of these analyses may be made for Japan as a whole, or for special seismic districts; in the former case the object being to determine whether the occurrence of earthquakes is dependent upon influences which simultaneously affect Japan as a whole, and in the latter case to determine how far their frequency may be related to phenomena of a more local character.

As an example of an influence which affects Japan as a whole, the difference in the summer and winter barometrical gradients crossing the country may be taken, while tidal loads along the coast would be expected to produce effects in different districts at different times.

Not only is it open for us to determine effects due to external influences, but these, so far as possible, must be distinguished from effects resulting from internal conditions. The great frequency in District 7 was entirely due to the shocks succeeding a terrible disturbance which took place on October 28, 1891; and if these after shocks, which at first occurred at the rate of 1,700 per month, and which apparently result from the settlement of disjointed strata, are included in any general list, it is clear that they might accentuate or destroy any law respecting a long period frequency. What is true for District 7 is also true for District 11. By themselves they yield information about the rate at which an enormous quantity of broken-up strata settles to a state of equilibrium, and because the district around the epicentrum is for some time after the primary disturbance in an extreme state of seismic sensibility, it is quite possible that there may be fluctuations in the rate at which quiescence is approached, due to external influences. Other problems which suggest themselves are the possible relationships between the seismic activity of the various districts, the times taken for different areas under the influence of secular movement to attain varying degrees of seismic sensibility, and the connection between earthquake occurrence and the geotectonic character of the country. If the object of an analysis is to discover a relationship between earthquake frequency and exogenous phenomena which recur at long intervals, it would seem advisable to omit long lists of after shocks, and only to take into consideration disturbances which occur in districts where seismic activity is in a normal state. On the contrary, should we seek a relationship between the occurrence of earthquakes and phenomena which recur at intervals of not more than a few days, as, for example, barometrical fluctuations or the rising and falling of the tide, this precaution is hardly necessary.

Place	District	High Water, Full and Change
		h. m.
Nemuro	1	4 9
Tsugaru Strait	2	5 0
Hachinohé	3	4 40
Yamada	4	4 15
Kinkasan	5	4 30
Inuboye-saki	6	5 45
Yedo Bay	6	5 45
Mia-ura	7	6 00
Kii Channel	8	6 00
Bungo Channel	9	6 00
Kagoshima Bay	10	6 50
Shimabara Gulf	11	9 22
Idzumo Coast	12	1 20
Echizen Coast	13	2 00
Toyama Bay	14	3 06
Off Niigata	15	2 55

For the latter investigation, the most desirable lists to use would be those referring to shocks originating beneath the ocean or along the seaboard, and as an assistance to this I give the preceding table, showing the times of high water at full and new moon on the coasts for the fifteen seismic districts shown in the small map.

Nothing has been said about the possible relationship between earthquakes and volcanic eruptions, first, because we have no reason to believe that, with the exception of a few feeble shocks which may precede or accompany an eruption, there is any marked direct connection between these two phenomena, and secondly, because the present catalogue does not extend over a sufficiently long period of years to lend itself to such an investigation. Although one or two new investigations have been here suggested, the principal work will be a repetition of old analyses, taking advantage of the fact that we are now able to deal with natural districts, to give earthquakes, where required, relative *weights*, and to distinguish between after shocks, the occurrence of which is but little influenced by epigenic actions of long periodicity, and those of a district where seismic strain is in a normal condition.

As to whether seismology will be advanced by carrying out these and other inquiries which may present themselves is a question which cannot yet be answered. It may be or it may not be, but the catalogue, which could not have been compiled without the generous assistance of the Royal Society of London and the kindness of the director and officers of the Imperial Meteorological Department of Japan, by allowing access to their unequalled store of valuable facts, will, it is hoped, settle the question as to whether it is desirable to continue in its present form the largest and probably the most perfect seismic survey which has hitherto been attempted.

I am glad to say that some of the features presented by the catalogues are now being analysed by Dr. C. G. Knott, of Edinburgh.

(*d*) *Results already obtained or shown by the Catalogue and Map of Centres.*

After Shocks.—About the time that the catalogue was commenced, Mr. F. Omori undertook an examination of the shocks succeeding the great earthquake of October 28, 1891, which are now indicated upon the map in District No. 7. This he did, following up the investigation by an analysis of the disturbances since 1889 in District 11, a series which recently occurred in District 10, and another series belonging to a region lying between 8 and 9, which, although now quiescent, about forty years ago was unusually active. As an outline of Mr. Omori's investigations is published in the 'Seismological Journal,' vol. iii. p. 71, and in greater detail in the 'Journal of the College of Science,' vol. vii. Part II., it would be out of place to give any detailed reference to them here. Briefly, it seems that when a large disturbance is followed by a long series of after shocks the number of these is roughly proportional to the area first shaken, or what may provisionally be called the intensity of the initial impulse. The character of the curves which represent the frequency of the after shocks in relation to time is remarkably similar, and having determined by observation the form of the earlier portions of a frequency curve, it seems possible to roughly calculate, not only the number of shocks which will be experienced before the district settles to its normal state of seismic activity, but also the interval of time that will be involved in such an operation. For the earthquakes considered by Mr. Omori it may be concluded that the earth's crust had been so far fractured that there was an approximate similarity in the heterogeneity of the disjointed material, which therefore, as it settled, gave rise to after shocks following a somewhat similar law. Another observation was that the larger of the after shocks travelled to greater distances than their smaller companions, and in consequence there was a marked difference in frequency at places situated at different distances from the primitive origin. If there is any law in this decrease in frequency with distance, then the frequency of what are evidently after shocks observed upon a coast line, as in Districts 1 and 10, might enable an observer to make a rough estimate of the distance of an inaccessible submarine origin. That satisfactory results would be obtained from such an investigation is, however, doubtful.

Distribution of Earthquakes.—An inspection of the map of earthquake origins or centres shows that the central portions of Japan, which are the mountainous districts where active volcanoes are numerous, are singularly free from earthquakes. The greater number of disturbances originate along the eastern coast of the Empire, and many of these have a submarine origin. That very few earthquakes are shown on the coast line between Districts 1 and 2 is in a great measure due to the fact that in this region there are but few observing stations, the island of Yezo in which these districts are situated being sparsely populated. A line drawn from N.N.W. to S.S.E., or from numbers 7 to 557, is the chief anticlinal axis of the northern island, and from the southerly prolongation of this beneath the ocean, earthquakes from time to time originate, which shake, not only the eastern coast of Yezo, but also many of the districts on the main island. Although districts like 11, 9, 8, and then through 7, suddenly northwards up to 13 or 14, lie along the strike line of the southern portion of the Empire, a greater number of earthquakes seem to originate from the face of the steep monoclinal slope which Japan presents towards the Pacific Ocean.

Lines, 120 geographical miles in length, running in an easterly or south-easterly direction from the highlands of Japan into the Pacific Ocean, like similar lines drawn from the Andes westwards into the same ocean, have a slope of 1 in 20 to 1 in 30, and in both of these districts earthquakes are frequent. On the contrary, along the face of flexures which are comparatively gentle, being less than half these amounts, which may be seen along the borders of most of the continents and islands of the world, earthquakes are comparatively rare. The inference from this is that, where there is the greatest bending, it is there that sudden yielding is the most frequent. In the case of many of the Japanese earthquakes, this takes place along the face of a monoclinal feature of the world's surface, and the intimate relationship between monoclines and faults is known to all geologists, the former being, in the words of Sir Archibald Geikie, an incipient stage of the latter.

Earthquakes and Secular Movements.—Another feature indicated by the map or known to the writer from personal observation is that earthquakes are frequent in those districts where there are evidences of secular elevation or depression, that is to say, in those districts where movement of the earth's crust is yet slowly taking place.

In Districts 1, 2, 5, 6, and 7 the writer knows from repeated observation that there are evidences of very recent elevation, and certainly in these districts earthquakes are extremely frequent. The signs + and — in the neighbourhood of Districts 8, 9, 11, 12, and 13, and along the Inland Sea, lying to the north of 8 and 9, but to the south of 12, also show a like relationship.

The only exceptions to the general rule appear to be the westerly portion of the district between 12 and 13, where there are evidences of secular movement, and earthquakes are of rare occurrence, and 1 in 5 cases where these conditions are reversed. The district No. 14 presents a series of earthquakes originating along the line of a valley between high mountains running from N.N.E. to S.S.W. Another good example of earthquake fracturing following a line of weakness down a valley between high mountains until it reached the plain was the disturbance of October 28, 1891, which, as has been explained, resulted in the abnormal conditions shown in District 7.

In Japan, therefore, earthquakes have been frequent along the steep monoclinal face of the country, in the synclinal trough of deep valleys, possibly along the continuation of the Yezo anticlinal, and in districts where secular movement is in progress. In Italy earthquakes originate along the anticlinal of the Apennines, and from what we know of the geological history of the country, which had its greatest growth in Tertiary times, and from the bradyseismic movements on the coast, it is not unlikely that the shakings it experiences announce the fact that secular yielding is yet in progress. The earthquakes of Switzerland and those which shake the Himalayas, and the younger mountains of the world, may also be taken as due to orogenic causes which seem to be so actively in operation in Japan.

Earthquake Sounds.—A map which has been prepared, but which has not been reproduced with the catalogue, shows the distribution of earthquakes accompanied by sound phenomena. To indicate that a sound was heard, a dot is used, for a sound with a shock the sign +, for a sound before a shock the sign —, while for a sound after a shock the sign |. After a volcanic explosion it might be expected that a sound wave propagated through the atmosphere would succeed a trembling of the ground.

As the latter sign occurs but seldom, although there are one or two cases of its occurrence in Districts 6, 7, 12, and 14, generally near active or old volcanoes, and about two cases in District 8, it may be assumed that earthquake sounds, rather than representing atmospheric waves radiating from an epifocal area, represent elastic vibrations transmitted through the ground, and therefore arrive at a given station in advance of any quasi-elastic surface undulation. Inasmuch as earthquake sounds only travel a few miles from their origin, the intervals between them and an earth movement which can be felt are very small. The result of this is that it often appears that the two phenomena are simultaneous, and therefore on the map we find nearly as many signs indicating 'sound with shock' as those which indicate 'sound before shock.' Sounds are often heard which cause people to run from their houses, expecting a shock which does not come. The dots on the map represent sounds which have been to ordinary observers simultaneous with an actual shaking of the ground. Taking the districts in order, we find the sound phenomena distributed as follows :—

1. Sounds fairly frequent on the coast at the most easterly and most southerly portions of the district. Inland and on the northern coast they are rare. This may indicate that the majority of earthquake origins lie to the S.E. and are submarine.

2 and 3. Sounds are rare. Many of the origins of these shocks are submarine. The coast between 2 and 3 is composed of soft materials.

4 and most easterly part of 5. Here the coast is rocky, built up of Palæozoic strata. Sounds are fairly frequent. In the southern part of 5, where there is much soft Tertiary material, sounds are rare.

6. Sounds are frequent in the northern part of the district, which is mountainous, while in the plain of Musashi, constituting the southern part, they are rarely heard.

7. Amongst the Palæozoic hills of the district, and extending down into the plain, sound phenomena accompany about 30 per cent. of the disturbances.

8 and 9. Although the districts are mountainous, sounds are rarely heard. Possibly the shocks originate beneath the ocean.

10, 11, and 12. Sounds are fairly frequent.

13. Here, which is another mountainous region, sound phenomena are common.

14. Sound is occasionally heard.

15. Along a sandy coast bordering a plain, sound phenomena seem never to be heard

Generally sound is heard in rocky mountainous districts, while on the alluvial plains it is but very rarely observed.

Earthquakes which have been propagated to Europe.—The object in appending to the catalogue a list of earthquakes which was kindly drawn up for me by Dr. E. von Rebeur-Paschwitz is to show that some of the Japanese disturbances have travelled as far as Europe, where for minutes or hours, although they were unfelt by persons, they caused movements in delicately adjusted horizontal pendulums. A similar series of unfelt disturbances originating in distant countries or beneath the oceans have been recorded in Japan.

IV. On the Velocities with which Waves and Vibrations are propagated on the Surface of and through Rock and Earth. (A Compilation.)

Introduction.

Because the observations which have been made upon the rate at which waves and vibrations are transmitted through rock and earth are so varied and often apparently contradictory, it has been thought advisable to select from the vast amount of material which is at our command a series of illustrations from experiments upon artificially produced disturbances, and from the records of actual earthquakes in which personal and instrumental errors have been small.

Amongst the real or apparent difficulties are the following :—

1. Along the same path, earth waves, originating from a powerful

impulse, travel at a higher rate than those resulting from an effort of lower intensity. 2. Near to an origin, the velocity of propagation is greater than it is between points at a distance. 3. After a disturbance has decreased in its speed of transmission it may be accelerated, and this acceleration cannot be with certainty attributed to its having entered a more elastic medium. 4. As an earthquake radiates, it is preceded by a series of minute tremors, the velocity of propagation of which is certainly very much higher than that of the main disturbance.

(*a*) *Artificially produced disturbances.* 1. *Experiments of* Mr. R. Mallet.

In the experiments of the late Robert Mallet conducted at Killiney Bay, Dalkey, and Holyhead ('British Association Report,' 1861) the initial impulse was caused by the explosion of charges of gunpowder. The electrical contact which caused the explosion released a chronograph which was stopped by an observer directly he saw, by means of a microscope magnifying 11·39 times, an agitation caused by the resulting waves in a dish of mercury. After corrections for the intervals of time thus noted, in round numbers the results obtained were as follows :—

In wet sand	0·251 km. per. sec.
In discontinuous granite	0·398 " " "
In more solid granite	0·507 " " "
In granite at Holyhead (mean) . . .	0·371 " " "

The charges of powder employed varied between 25 lb. and 12,000 lb., and with but one exception it was clearly shown that the velocity of wave propagation increased with the force of the initial impulse. For example, at Holyhead the relationship between the quantity of explosive and the resulting velocities was as follows :—

Powder in lb. . . .	2100	2600	3200	4400	6200	12000
Velocity in km. per. sec..	0·335	0·338	0·310	0·344	0·406	0·418

2. *Experiments by* General H. L. Abbot.

In 1885 when Flood Rock was destroyed by the explosion of 240,397 lb. of *rack-a-rock* and 48,537 lb. of dynamite, the most distant observing station was 182·68 miles off. The instant of the explosion was noted at all the points of observation by means of electrical connections and chronographs, while the arrival of the first tremors and their duration was recorded by observers who watched the disturbance of an image reflected from the surface of mercury.

The Hallet's Point observations, where the initial impulse was due to the explosion of 50,000 lb. of dynamite, and others made in connection with subaqueous explosions at the school of submarine mining at Willet's Point, were conducted in a somewhat similar manner. In the following table, which has been drawn up from the scattered writings of General Abbot, the velocities have been reduced to uniform units :—

—	Distance in miles	Magnifying power of telescopes	Mercury in agitation sec	Velocity in metres per sec.	
1 Flood Rock ex. 288,934 lb. of explosive.	8·33	14	80	1,577 m.	Easterly through drift.
2 ,, ,,	16·78	14	104	1,086 m.	,, ,,
3 ,, ,,	36·65	18	35 ?	4,537 m.	,, ,,
4 ,, ,,	48·52	19	54	5,068 m.	,, ,,
5 ,, ,,	144·89	15 ±	74	3,958 m.	,, ,,
6 ,, ,,	182·68	750	95 +	1,335 m.	,, ,,
7 ,, ,,	42 34	31	76	5,003 m.	Northerly through rock.
		16	70	6,243 m.	
		36	92	6,243 m.	
8 ,, ,,	174·37	25/46	49 +	6,210 m.	,, ,,
9 Hallet's Pt. ex. 50,500 lb. dynamite.	5·13	6	63	1,180 m.	Through clay and drift.
10 ,, ,,	8·33	12	72	2,530 m.	Through water & shore of East river.
11 ,, ,,	9·33	6	23	1,378 m.	Through clay and drift.
12 ,, ,,	12·76	12	19	1,618 m.	,, ,,
13 400 lb. dynamite.	1·17	6	8	1,045 m.	,, ,,
14 ,, ,, ,,	1·17	12	18	2,686 m.	,, ,,
15 200 ,, ,,	1·34	6	9	2,051 m.	,, ,,
16 ,, ,, ,,	1·34	12	17	2,662 m.	,, ,,
17 ,, ,, ,,	5 ±	12		1,609 m.	,, ,,
18 70 lb. powder.	1·40	6	inst.	378 m.	Charge submerged 5 feet.
19 ,, ,, ,,	1·34	6	5	1,694 m.	Charge on bottom in 30 feet of water.
20 ,, ,, ,,	1·34	12	15	2,565 m.	

From the above data it is clear, as Abbot shows, that the rate at which a shock is transmitted increases with the intensity of the initial explosion; that when a high magnifying power has been used, tremors in advance of those revealed by a low power have been noticed, with the result that the apparent velocity in the former case is greater than in the latter; and that the velocity of propagation has been higher through rock than through soft material like drift.

A query put forward by General Abbot is whether still higher velocities would have been recorded had telescopes with a greater magnifying power been used. The answer is apparently in the affirmative, and therefore if we wish to compare the observations amongst themselves, not only must we choose those in which the initial impulse has been the same, but where the observers have employed similar instruments. Comparing observations 10 and 12, but not overlooking the fact that No. 10 was largely transmitted through water, and again 16 and 17, it might be concluded that as a wave advances its velocity is diminished; but from the first five observations it would seem that there is at the commencement an increase in the initial velocity until it reaches a maximum, after which there is a diminution. This increase in the rate of transmission at the outset of a wave from its origin is again seen in experiments 9 and 11. The difference in the velocities recorded for experiments 18 and 19 may be due to the fact that in the case of the shallow torpedo much of the initial energy was expended in throwing up a jet of water 330 feet in height into the air. A point well worthy of notice is the fact that the gunpowder waves had a more gradual increase than those observed in shocks produced by dynamite ; in other words, the former had a closer relationship to what is so often observed in the records of actual earthquakes than the latter had.

3. *Experiments of* MM. Fouqué *and* Lévy.

In the experiments of MM. Fouqué and Lévy the velocity of vibrations on the surface and underground was determined by recording the intervals between the shock which was usually produced by the explosion of from 4 to 8 kilos. of dynamite, and the displacement of an image produced by a ray of light on a photographic plate moving with uniform motion. The ray of light was reflected from a surface of mercury at the receiving station. The highest velocity was obtained between a point underground and the surface, along a line of 383 metres in length, which gave a velocity of 2,526 metres. In this case the shock was due to an explosion of 8 kilos. of dynamite.

The general results obtained were as follows :—

Character of Ground	Velocity of first tremors	Velocity of last tremors
	m. m.	m. m.
1. In granite on the surface	2,450 to 3,141	219 — 108
2. Underground to surface and underground to a greater depth	2,000 to 2,526	1,212 — 440
3. In *grès permiens* not so compact . .	1,190	—
4. In limestone from surface to underground	632	—
5. In *sable de Fontainebleau*	300	—

The velocity evidently increased with an increase in the amount of explosive employed, and it was greatest in the more elastic rocks.

The discrepancy which exists between the above and Mallet's determination for granite (507 m.) only disappears if we compare it with the second maximum in the photographic record (325 m. to 543 m.).

The second set of experiments, considering the nature of the material in which they were obtained and the smallness of the charges employed, give remarkably high results, the velocity for the first maximum exceeding that obtained by firing a larger charge of dynamite in granite on the surface. In a single experiment to determine the velocity between a lower and a higher level underground, the direction of the wave path is unfortunately not very different from that of the stratification, and therefore is not comparable with those velocities along paths from the upper level nearly transverse to the stratification between it and the surface. If we are allowed to accept the results of Mallet's experiments, which show that the velocities in these two directions are in round numbers as 1·8 : 1·0, then we may conclude that the velocity between the lower level and an upper level was markedly greater than it was from the latter upwards to the surface.

These experiments show that the velocity between two points on the surface is less than it is between the surface and a point underground. They also indicate that the velocity with which vibrations are transmitted may vary with the depth of the wave path.

4. *Observations of Prof.* J. MILNE *and Prof.* T. GRAY.

In the author's experiments, which were commenced in conjunction with Professor Thomas Gray in 1881, and continued at various times during the next four years, the object was not simply to determine the rate of transmission of earth waves, but also to determine their general character. Usually the movements resulting from the fall of a heavy weight, or the explosion of dynamite or gunpowder, were recorded by seismographs. The weights employed varied from 1,710 lb. to 2,000 lb., while the charges of dynamite, which were exploded in holes 8 or 10 feet in depth, seldom exceeded 2 lb. Although the ground in all cases excepting one was soft, the resultant vibrations up to distances of about 600 feet were sufficiently large to be recorded as clear diagrams by bracket and other seismographs.

At various stations usually in a straight line joining them with the focus of the explosion, seismographs were installed, which wrote their movements on the smoked surface of a long plate of glass, the motion of which was controlled by clockwork. One seismograph was placed so that it wrote the movements parallel to the line of installation. These are called normal vibrations. A second seismograph was arranged to record the movements at right angles to such a direction. These are called transverse vibrations. A vertical lever seismograph was occasionally employed to give the vertical motion. A fourth pointer actuated by an electromagnet in connection with a short pendulum swinging across mercury gave a broken line marking small but equal intervals of time.

By the depression of a contact key, the receiving plates at all the stations were set in motion, the pointers of the seismographs drew fine straight lines on the smoked surfaces, while the pendulum indicated intervals of time. A few seconds later a second contact was made and the charge exploded, and the seismographs gave open diagrams of the resulting vibrations. When the earth motion had ceased, all the plates were stopped and were ready to receive a second diagram without any readjustments. One observer controlled all the stations, and the only errors due to human interference may have arisen from slight differences in the sensibilities given to the recording instruments. This, however, disappears when velocities were determined, not from the commencement of a disturbance, but from the sharp commencement of the violent vibrations or from the intervals of time between the appearance of particular waves at the different stations.

Observations were also made with seismographs having single indices by observing the disturbance created in similar dishes of mercury, and with other arrangements.

The results of observations made respecting velocity of propagation were as follows :—

1. The velocity of transit of vertical vibrations near to an origin decreases as a disturbance radiates. Normal vibrations, although they have shown a decrease in velocity between the second and third stations, have also shown a decided increase. This latter observation has been marked with the transverse motions.

2. Near to an origin the velocity of transit varies with the intensity of the initial disturbance.

3. In different kinds of grounds, with different intensities of initial

disturbance, and with different systems of observation, I determined velocities lying between 630 (192 m.) and about 200 (61 m.) feet per second.

4. In my experiments the vertical free surface wave had the quickest rate of transit, the normal being next, and the transverse motion being the slowest.

5. The rate at which the normal motion outraces the transverse motion is not constant.

6. As the amplitude and period of the normal motion approach in value to those of the transverse motion, so do the velocities of transit of these motions approach each other.

(*b*) *Observations on Earthquakes.*

The observations quoted in this section commence with those where the wave paths have not been more than a few hundred feet from station to station. These are followed by the results obtained from instruments separated from each other by distances of from three to six miles, a few hundred miles and so on up to velocities determined over paths equal to a quarter of the earth's circumference.

1. *Observations in Japan.*

For several years the author took diagrams of earthquakes at seven stations, each about 900 feet apart. These stations were in electrical connection, so that one pendulum marked time intervals upon each of the moving surfaces upon which diagrams were being drawn. From fifty sets of diagrams, representing fifty different earthquakes, it was only in five instances that the same wave could be identified at the different stations. The result of these identifications led to calculation of velocities of 1,787, 1,302, 1,825, 869, and 501 metres per second.

Even these determinations cannot be accepted without reserve, because it is found that waves may spread out as they pass from station to station, a given wave splitting up into two waves, &c. *Hence a velocity calculated from a wave* (a) *may be different from a velocity of a wave* (b), *and yet both are part of the same disturbance.* In the diagram from one station a large wave may have a slight notch upon its crest, at another station this notch is seen to have increased in size, while at a third station it is so large that the single wave appears as two waves. As in the artificially produced disturbances, although an earthquake becomes feebler as it radiates, it *apparently* increases in its duration.

The same system of observation has recently been elaborated in Japan, but the distances between stations have been increased to several miles. Because the commencement of a disturbance at a given station varies with the sensibility given to the seismograph, the determinations of velocity depend upon the identification of particular waves upon the diagrams obtained from at least three stations. Up to the present this has only been possible on one or two occasions. On November 30, 1894, at 8.30 p.m., a velocity of 5 km. per second was obtained, other disturbances giving from 2·4 to 3·6 km. per second.

The following are examples of velocity determinations made in Japan between stations which have access to the telegraphic system of the country, and which are provided with seismographs and clocks which automatically record the time at which a particular vibration was drawn. At each of the observatories it is therefore possible to calculate the instant at which a given instrument commenced to write its record.

In 1891, on December 9 and 11, strong shocks originated in the province of Noto on the west coast, which were observed in Gifu, Nagoya, and Tokio. The mean velocity determined from these records was 2·31 km. per second.

The destructive disturbance of October 28, 1891, which was recorded in Europe, was followed by many after shocks, the times of arrival of seventeen of which were accurately noted at Osaka, Nagoya, Gifu, and Tokio. The origin of the main shock was about five miles to the west of Gifu. To reach Tokio, a distance of 151 miles, took 120 seconds. The average time taken for all eighteen shocks was 118 seconds, and the average velocity was 2·40 km. per second, the rate of transmission to Osaka being the same as it was over the much longer path to Tokio.

The primary disturbance seems to have reached Shanghai at a rate of about 1·61 km. per second, and Berlin at about 2·98 km. per second. For the Shōnai shock on October 22, 1894, as a mean obtained by the method of least squares from observations at ten stations from 60 to 300 miles distant from the origin, a velocity of about 1·95 km. per second was obtained.

Giving these last determinations, all of which were computed by Mr. F. Omori, weights proportional to the number of observations each represents, the average rate at which disturbances are propagated over long distances in Japan is 7,560 feet, or 2·3 km. per second, a rate which fairly well agrees with that at which the large waves of similar disturbances travel from Japan to Europe.

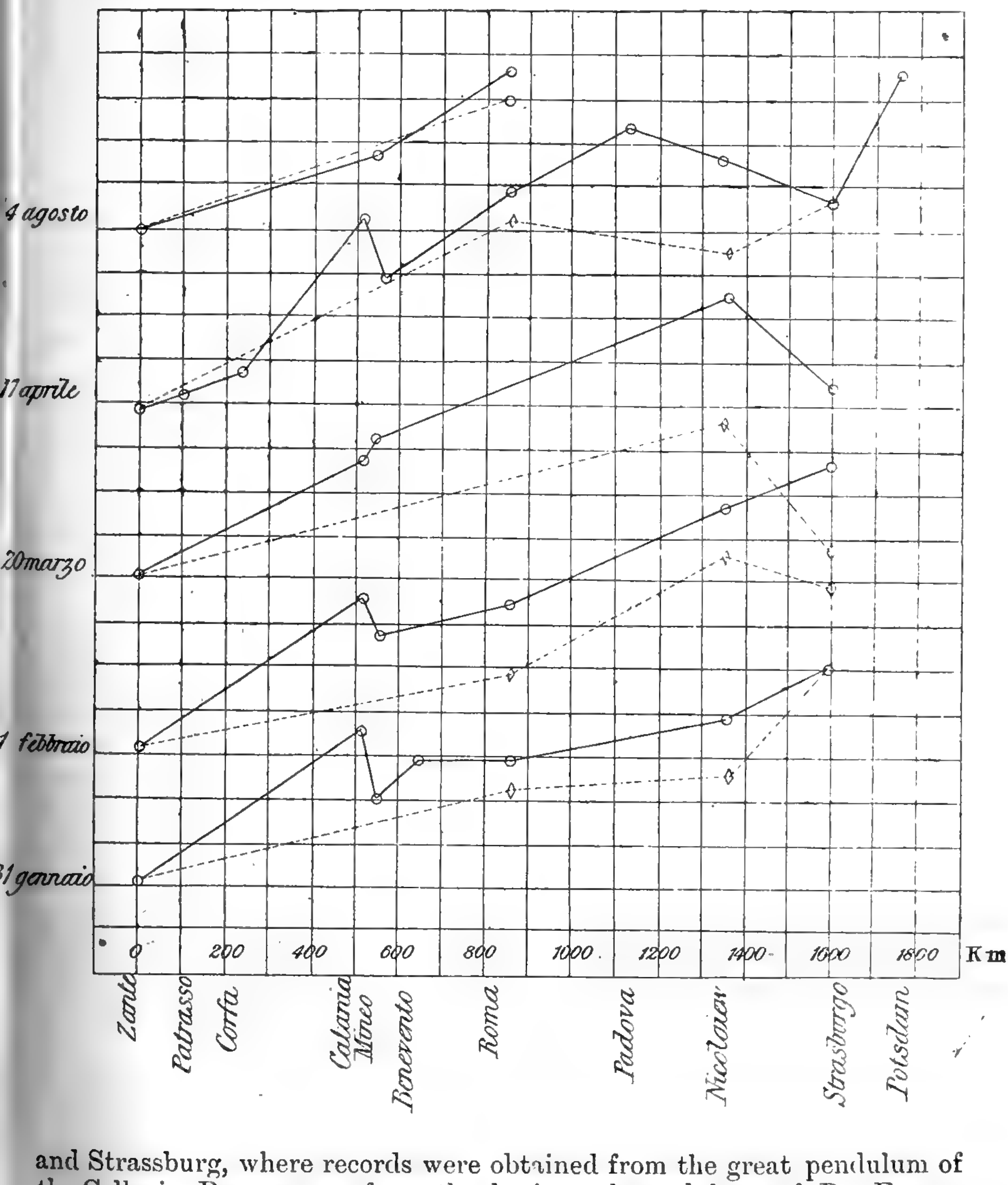
2. *Observations along Wave Paths of Great Length.*

Next we will turn to earthquakes which have been noted at distances from their origins greater than those at which it has been possible to observe in Japan—a notable example of which are the observations made at the time of the Charleston Earthquake on August 31, 1886. Over 400 observations were made. A number of these were obtained from clocks which had been stopped, and as many of these were regulators which had daily been compared with a time signal, there is no reason to doubt their accuracy. All these observations, which were made on wave paths between 300 and 924 miles in length, were subjected to a rigorous analysis by Professor Simon Newcomb and Captain Charles Dutton, with the result that an average velocity of 5,184 m. was determined, and there was no indication of any sensible variation in speed. Considering the phase of motion which in the majority of instances was in all probability observed, this result is remarkably high.

A valuable study of the rate at which vibrations may be propagated through the earth's crust is one made by Dr. G. Agamennone of a series of shocks which in 1893 had their origin near to the island of Zante. These were recorded at the various stations mentioned along the foot of the diagram Fig. 15, the one farthest from the origin being Potsdam. The lengths of the various wave paths are indicated in kilometres. The time intervals measured vertically are on a scale of 20 seconds per millimetre. For five shocks straight lines connect a series of points indicating the differences in time between the occurrence of the shock near to its origin and the time at which *maximum* motion was experienced at the various stations.

The dotted lines connect similar points for the *commencement* of the disturbance. The time of these commencements undoubtedly varied with the sensibilities of the recording instruments, and therefore it will be noticed that they have only been taken into account for Rome, Nicolaiew,

FIG. 15.



and Strassburg, where records were obtained from the great pendulum of the Collegio Romano, or from the horizontal pendulums of Dr. E. von Rebeur-Paschwitz.

The principal object in reproducing this series of observations is to see if there is any reason for believing that there is any variation in the velocity with which a given disturbance is propagated.

In examining this diagram it must be remembered that near to an origin the difference in time between the maximum phases of an earthquake and its actual commencement may be only a few seconds, while at a great distance the records of sensitive instruments show that the same interval may be many minutes. When instruments of such sensibility are near to an origin, my own observations seem to show that they are not set into any sensible amount of motion before the ordinary seismoscopes or seismographs, and therefore for places comparatively near to the origin of a disturbance, when observations were made with the latter type of instrument, I should be inclined to think that the phases of maximum motion might be *approximately* coincident with the times of commencement of movement.

An inspection of the diagram points towards the following results :—

No. 1. The velocity for the first 550 km. is greater than it is to a point which is more remote.

No. 2. This is the only disturbance for which observations are made at points comparatively near to the epicentre, for which they show a very high velocity. Between stations distant 300 and 1,100 km. from the origin the velocity decreases, but beyond this limit it apparently increases.

No. 3. The chief difference between this and No. 2 is that the point of inflexion of a free curve drawn between the points of observation, instead of being at a distance of 1,100 km. from the epicentre, is at about 1,300 km. from that point.

No. 4. The velocity is apparently greater at a distance from the epicentre than near to it.

No. 5. This resembles No. 4.

If we omit the one case which shows a high velocity in the immediate neighbourhood of the origin—which, however, is in perfect accordance with results obtained with artificially produced disturbances—there remains the clearly marked observation that to Catania and Mineo the velocities are, as compared with the rate of propagation to more distant stations, relatively low. Professor A. Ricco, who discusses these observations, gives us every reason to believe that the time observations at Catania are correct, while those at Mineo may be in error, owing to the manner in which it receives the time signals from Rome, which finally reach the observatory by *circolare*.

Professor Ricco concludes that the low velocity between Zante and Catania may be accounted for by the fact that the motion was entirely transmitted through water, because the velocity recorded of 1,439 km. per second practically coincides with that of a sound wave in water. Professor Ricco adds that Bertelli has shown that the shocks of earthquakes felt on shipboard and the sound waves have been simultaneous. From one of Abbot's experiments, however, we have seen that a wave velocity obtained from a water path was greatly increased.

The following is Agamennone's table of velocities, which, although they represent averages, show that the lowest is the one on August 4, which had the shortest range :—

Date	No. of Stations considered	Velocity of Max. Motion based on all Observations. Km.	No. of Stations considered	Velocity of Max. Motion based on certain Observations. Km.	No. of Stations considered	Velocity of Commencement of Motion at Certain Stations. Km.
Jan. 31 .	7	4·04	4	2·86	4	3·08
Feb. 1 .	6	3·28	4	2·42	4	3·92
March 20 .	5	2·33	3	2·82	3	7·79
April 17 .	10	2·55	5	2·59	5	3·16
August 4 .	3	2·12	2	2·36	2	2·83
Mean .	—	2·40	—	2·45	—	2·34

The averages of velocities to the Italian stations and the actual velocities to Mineo and Catania, which may be compared with the first determination in the preceding table, clearly show that the apparent velocity to the nearer stations was lower than it was to stations which were more distant :—

—	Italian Stations. Km.	Mineo. Km.	Catania. Km.
January 31	3·76	1·83	1·14
February 1	4·26	2·04	1·43
March 20	1·86	1·77	1·98
April 17	2·09	1·96	1·20
August 4	2·12	3·05	—

Dr. A. Cancani, who has devoted much attention to the velocities with which earth disturbances are transmitted, is apparently inclined to attribute the high velocities sometimes observed near to an epicentre—which, however, is not the case with those just quoted—to the more rapid transit of a longitudinal wave. He, however, adds that at such places, and even at distant places, the normal and transversal waves may occur together, and the velocities determined on such occasions will have intermediate values. In fairly homogeneous earth it has been shown that, within 100 feet or so from the origin of an artificial disturbance, a normal movement outraces the transversal disturbance, but such a separation is not observed, nor should we expect it to be observed, at distant stations (see pages 162 and 163).

When Dr. Cancani quotes my opinions that 'velocities of 2 or 3 km. per second refer to the propagation of a motion not unlike the swell upon an ocean' as not being contrary to his ideas, it must be clearly understood that I do not refer such movements to the purely distortional elastic waves of an isotropic solid.[1]

Amongst other observations quoted by Dr. Cancani to show that the velocity with which earthquake waves are propagated is higher nearer to an epicentre than at a distance, I select the four following, which have reference to the Andalusian disturbance of December 25, 1894 :—

To Lisbon,	distance	530 km.	velocity in km.	per	sec.	4·2
,, Parc St. Maus,	,,	1,350	,,	,,	,,	3·2
,, Greenwich,	,,	1,620	,,	,,	,,	3·6
,, Wilhelmshaven,	,,	2,000	,,	,,	,,	2·8

[1] *R. Accad. dei Lincei*, vol. iii. 1894, p. 410

Dr. Agamennone, after examining the data on which these tables are founded, shows that the conclusion to which they point disappears if the time taken at Cadiz by the stopping of two clocks was a minute too late, while the times at Greenwich and other observatories correspond to the beginning of the motion. From the calculations of Offret relating to the Ligurian earthquake of February 23, 1887, it would appear that the velocity of propagation *increased* as a disturbance radiated, but such anomalies may also be explained by the assumption that there were errors in the time observations near to the epicentre.

As another indication of what is apparently the reverse of the results adduced by Dr. Cancani, we may take either the earthquakes of Zante or the following Japanese earthquakes, observed in Europe by Dr. E. von Rebeur-Paschwitz :—

Date	Locality	Spherical Distance. Km.	Velocity in km. per sec.
1889, April 17	Potsdam, I.	8,950	3·23
	,, II.	,,	2·79
	Wilhelmshaven	9,070	3·50
1889, July 28	Potsdam	8,810	2·98
	Wilhelmshaven	8,940	3·31
1892, May 11	Strassburg	9,520	3·07
	Nicolaiew, I.	7,910	2·75
	,, II.	,,	2·41
1892, October 18	Strassburg	9,520	3·83
	Nicolaiew, I.	7,910	2·55
	,, II.	,,	2·24
1892, November 4	Strassburg, I.	9,520	3·15
	,, II.	,,	2·64
	Nicolaiew	7,910	2·71
1893, March 23	Strassburg, I.	9,520	4·13
	,, II.	,,	3·62
	Nicolaiew	7,910	3·72
Average			3·10

The centre of the second disturbance is taken near to Kumamoto, while that of the others as being near to Tokio.

Arranging the above according to distance, we find :—

6 observations for	7,910 km.	give a velocity of	2·73
5 ,,	8,900 ,,	,,	3·16
6 ,,	9,520 ,,	,,	3·41

The numeral I. refers to the greatest increase in motion, while II. refers to the maximum itself, and it will be observed that the value for II. is always less than it is for I.

A good series, showing the widely different results which may be obtained as to the velocities with which given disturbances are propagated, may be found in the British Association Report of the Committee on Earth Tremors for 1894. The earthquakes to which these refer are those of April 20 and 24 of 1894, which originated in North-east Greece, and which were recorded by different types of instruments at 41 different stations in Europe, the length of the wave paths being from 701 to 2,455 km. The velocities obtained vary between 1·29 and 11·71 km. per second. The high velocities are those obtained from records of the *com-*

mencement of movement by the more sensitive classes of instrument, the records from which also give the lower values, if the arrival of the disturbances is taken as being the time when they recorded maximum phases of motion.

As a last example of the different results which may be obtained from the same record, I take that observed at Rocca di Papa on March 23, 1894. The shock originated beneath the ocean about 70 miles S.E. of Nemuro, on the north-east coast of Yezo (Lat. 42° N., Long. 146° E.). It was observed at Nemuro in Greenwich mean time at 10.20.45 A.M.

The times at Rocca di Papa and the resulting velocities were as follows:—

First tremors,	10.36.0 G.M.T.	11·35 km. per sec.
Decided motion,	11.12.0 ,,	3·06 ,,
Maximum motion,	11.19.0 ,,	2·69 ,,

In Tokio it was observed at 10.27.40 G.M.T., after which four after-shocks were noted. The average time difference between the observations at Tokio and Nemuro was 6 min. 43 sec., and the difference in their distances from the origin is about 600 miles, from which an average velocity of about 2·3 km. per second is calculated. If it is assumed that the first tremors reached Rocca di Papa by direct radiation along a chord or *through the earth*, then their velocity may be reduced to 8 or 10 km. per second (see example on p. 149).

3. *Conclusions.*

Very many records might be added to those which have been given, but it does not seem likely that, until we are in possession of a series of records taken at long distances apart on the surface of our globe by means of instruments *which are similar, which have sufficient sensibility to record preliminary tremors, and which record upon surfaces moving sufficiently quickly to allow of accurate time determinations*, that our present knowledge will be greatly increased. Because the waves of a disturbance change in period as they travel, while one wave breaks up to form two or more waves, and this even in ground which is apparently homogeneous, a given earthquake may show as many velocities as there are waves between which we choose to make measurements. What we know from experiments, and what we should expect from *à priori* reasoning, is that the rate at which a disturbance is propagated varies with the nature of the medium through which it is transmitted. Experiments have shown that the vibrations following an artificial disturbance, where the initial impulse has been strong, travel more quickly than those where the originating cause has been feeble; also that there is apparently a higher velocity *very near* to an origin than at a distance. The latter phenomenon seems to find confirmation in the records of certain earthquakes. Although it may be difficult to interpret the meaning of these latter observations, when we endeavour to find an explanation for the existence of the long series of preliminary tremors which are recorded at places nearly a quarter of the earth's circumference from an origin, and which have apparently reached these places by travelling at rates of 9 to 12 km. per second, the difficulties which confront us are still greater. The next section is an attempt to explain these phenomena.

(c) *On the Probable Nature and Velocity of Propagation of the Movements resulting from an Earthquake Disturbance.*

If it is assumed that the crust of the earth has the character of an isotropic elastic solid, then from an earthquake centrum two types of waves may emanate. In one of these the direction of vibration of a particle is parallel to the direction of propagation of the wave or normal to its front, as in a sound wave, whilst in the other it is transverse to such a direction, or, so far as this character is concerned, it is like the movements in a ray of light.

These two types of movements, which are respectively known as condensational and distortional waves, are propagated with different velocities, which depend upon certain elastic moduli and the density of the material.

These velocities may be respectively expressed by the quantities $\sqrt{m/\rho}$ and $\sqrt{n/\rho}$, where ρ is the density of the material, n the modulus of rigidity or resistance to distortion, and m a modulus depending upon the modulus of rigidity and the bulk modulus or resistance to compression k, which is equal to $k+\frac{3}{4}n$.

The first conclusion to which the theory leads is that the condensational wave has a higher velocity than the distortional wave, and therefore the first ought to outrace the latter. With artificially produced disturbances *at points near to origins* in fairly homogeneous earth, a phenomenon similar to this has been observed, but whether the preliminary tremors preceding more decided movements observed at great distances represent condensational waves propagated from an origin is yet uncertain. From experiments made in conjunction with Professor T. Gray to determine the elastic moduli of granite, marble, tuff, clay rock, and slate, and the velocities with which normal and transverse movements have been propagated in alluvium, Dr. C. G. Knott drew up the following table as representing average constants involved when determining the velocities with which disturbances may be propagated through fairly solid rocks :—

Density	$\rho=3$
Rigidity	$n=1{\cdot}5\times10^{11}$ C.G.S. units
Ratio of the wave moduli	$m/n=3$

With the above numbers the velocity of a distortional wave would be 2·235 km. per second, while the condensational wave would have a value about double this quantity. Should we accept the records made of *decided* movements which had their origin in Japan, but which have been recorded in Europe as representing distortional waves, then our expectations based upon theory closely accord with what has been observed.

On the other hand, because it has been shown that small vibrations have been noted which have travelled at rates of from 9 to 12 km. per second, the fact must not be overlooked that we are not yet in possession of sufficient constants to apply the theory to all the cases which have been observed. Even if we had the constants referring to the elasticity and density of material in the interior of our earth, when we consider the heterogeneity of the materials through which a disturbance probably passes, as Dr. C. G. Knott and other writers point out, there are serious objections to the assumption that waves with a high velocity are due to the transmission of normal motions, while those with a lower velocity represent the less rapid transversal vibrations. At every boundary between two media different in their elasticity, either a condensational or a distortional wave is broken up into reflected and refracted distortional waves as well as reflected and refracted condensational waves, and therefore as a disturbance travels through the heterogeneous mass of materials constituting the earth's crust there is, in every probability, a continual change in the character of the motion.

Not only does this consideration make it appear unlikely that the tremors which have been observed at stations far removed from an origin if they were propagated on or near to the *surface* of the earth are due to condensational waves, while the more pronounced movements which succeed them represent the distortional waves, but it also indicates that at a given station there should be no definite relationship between the motion of an earth particle and the direction of propagation of an earthquake. For feeble earthquakes, and for those recorded at points outside a megistoseismic area, this latter conclusion is remarkably concordant with observation.

On the other hand, however, if preliminary tremors are movements which have been transmitted at *great depths* through a medium where $\sqrt{\epsilon/\rho}$ is constant or changes gradually, it is likely that they have a condensational character.

Next we may consider the probable nature of surface waves. Lord Rayleigh, in a paper on waves propagated along the plane surface of an Elastic Solid,[1] investigates 'the behaviour of waves upon the plane free surface of an infinite homogeneous isotropic elastic solid, their character being such that a disturbance is confined to a superficial region of thickness comparable with the wave-length. The case is thus analogous to that of deep water waves, only that the potential energy here depends upon elastic resilience instead of upon gravity.'

Two cases are discussed, but the results are very similar. A particle at the surface moves in an elliptic orbit with its major axis perpendicular. The displacement parallel to the plane surface penetrates into the solid for an incompressible solid about the eighth of a wave-length, and to about the fifth into the solid when the Poisson ratio has a value of one-fourth. The surface waves are propagated at a slightly slower rate than a purely distortional wave is propagated.

From observations made upon earthquakes near to their origin, it seems that when vertical motion appears it is accompanied by horizontal displacements greater than that required by the formula given by Lord Rayleigh, but the question arises whether the accepted horizontal movements are not more apparent than real, being displacements due to tilting of the recording instruments. That at the time of a strong earthquake surface waves have an existence, because they have been seen, been felt, and been recorded by instruments, is a fact not to be disputed. As they spread the distance between crest and crest apparently increases, and calculations have been made to determine their height and length. About the path described by a constituent particle nothing has yet been experimentally determined. The decided movements which have been recorded at great distances from their origin, which have been referred to as possibly being distortional waves, because they slowly tilt pendulums from side to side, are not unlikely to be *long flat undulations which near to the origin were decided surface waves.* If this is the case, the phenomenon to be

[1] *Proc. Lond. Math. Soc.*, vol. xvii. 1885–6.

investigated is not the transversal vibrations of a truly elastic solid, but it is a quasi-elastic surface disturbance, the propagation of which is accelerated by the influence of gravity.

The preliminary tremors have, however, yet to be explained. At stations within 100 miles of an origin, as recorded by seismographs, these outrace the main disturbance—with which, however, they are invariably connected—and often overlap it, by perhaps ten seconds. At a distance of 6,000 miles they seem to outrace it by half an hour.

Dr. C. G. Knott suggests that they are due to the quasi-elastic disturbances which accompany earthquakes. When the earth movement is violent, and possibly accompanied by destruction, the material of the earth's surface is either strained beyond its limit of elasticity, or at least so far strained that the resulting movements are governed by coefficients other than those due to rigidity and compressibility. As these quasi-elastic waves pass through a region of discontinuity, or as they lose energy, they may be suddenly or gradually transformed into a purely elastic disturbance.

Although changes of this description may take place as a disturbance passes from medium to medium, inasmuch as it implies the creation of tremors as the surface waves progress, much in the same way that a trotting pony or a railway train creates the sound waves which run before them, we are led to the conclusion that the preliminary tremors have a velocity very much higher than those already calculated. Because this cannot be accepted, the only explanation remaining is the assumption that the preliminary tremors are movements originating at an earthquake centrum and propagated possibly as condensational waves along paths yet to be discussed *through* our earth. If this is made, then apparent velocities of 11 or 12 km. per second, as observed for example on March 22, 1894, may be reduced to actual velocities of about 9 km. per second.

Should a more extended and systematic observation confirm this provisional assumption, we shall then be in a position to discuss from a new point of view the physical nature of the materials constituting the interior of our globe which apparently transmits motion at a greater rate than glass or steel.

Points not yet touched upon are the increase of velocity with an increase in the intensity of the initial disturbance, and a decrease in velocity as a disturbance radiates, both of which phenomena are marked near to the origin of artificial disturbances. The only explanation which suggests itself for both these phenomena is that around the epicentrum there is a region to which motion is communicated partly by elastic yielding and partly as a push. The volume of ground which may be thus disturbed is called by my late colleague, Professor T. Alexander, an earthquake core. In the case of an artificial disturbance originating near to the surface, the distance to which this effect extends will depend upon the suddenness and magnitude of the initial disturbance. With an earthquake originating underground, the distance to which a high epifocal velocity may be noticeable will not only depend upon the above two conditions, but also upon the depth of the focal origin. The greater this latter quantity becomes, the greater will be the radius of the epicentral area in which there may be not only a real increase in velocity but also a high *apparent* velocity.

The conclusion to which these considerations and the observations which have been made lead is that an earthquake gives rise to at least three kinds of movements, each of which has a different velocity of propagation. On the surface of the earth there is an undulatory motion which from the researches of Lord Rayleigh we might expect to travel at a rate slightly slower than a distortional wave, but as pointed out by Lord Kelvin it is probable that this rate is accelerated by the influence of gravity. What we should expect and what we find are therefore fairly in accordance. From a centrum to various points upon the surface of the earth we should expect truly elastic waves to be propagated, the velocities of which would vary along paths of varying depths. At great depths, as for example along a straight or curvilinear path between Japan and Europe, the velocity of propagation might be higher than that of a condensational rarefactional wave in glass, and exceedingly high velocities have apparently been observed. Lastly, in an epifocal area there may be instantaneous disturbance or an apparent high velocity due to bodily displacement within an earthquake core and the transmission of elastic and quasi-elastic vibrations, or to the combination of such phenomena.

(d) *The Paths followed by Earthquake Motion.*

What has next to be considered are the paths by which an earthquake originating at a centrum reaches various points upon the surface of the globe.

Three hypotheses present themselves. Motion may reach various points on the earth's surface along the rectilinear wave paths of Hopkins or Seebach, by curvilinear paths as suggested by Dr. A. Schmidt, or lastly by either of these paths, after which from an epifocal area the radius of which is not likely to exceed the focal depth, there is a transmission on the surface of elastic gravitational waves.

Before discussing the merits of these hypotheses, it may be well first to consider the case or cases to which they are applicable.

Because we have no evidence of a disturbance being simultaneously felt at a number of places on the surface of our globe and at their antipodes, and for other reasons, we may exclude the idea of a disturbance having originated near to the centre of our sphere. Nor can it be admitted that a disturbance originated at half or quarter such a depth, for if it did so, then in an epicentral area, possibly 400 miles in diameter, *apparent* velocities should have been observed which not only would be enormously high, but would be at least five times greater than those observed between more distant stations.

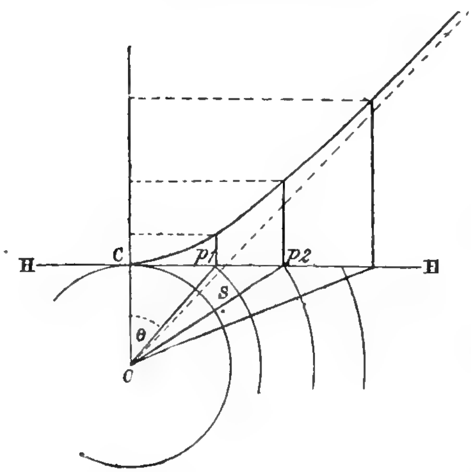
From what we know respecting the causes of earthquakes, it is a reasonable supposition to imagine that their origins are confined to the crumpling of a superficial layer of the material constituting the crust of our globe, which according to the Rev. O. Fisher and other investigators, in all probability does not exceed thirty miles in thickness. The enormous faulting which has accompanied certain disturbances shows that at least a portion of the initial impulse was delivered actually at the surface. About the depth to which such faults have descended or the mean depth from which an earthquake has originated, we have no certain information. Confining our considerations to disturbances which have originated at depths which are extremely small relatively to the radius of our earth, we may now turn to the hypotheses respecting earthquake radiation.

1. *Hypotheses of Hopkins and Seebach.*

In 1847 Hopkins drew attention to the fact that the velocity with which a wave passes from one point of the surface of the earth to another point is only an *apparent* horizontal velocity which may be denoted as v. For example, if in fig. 16 the origin of a disturbance be O, C be its epicentre on the surface of the earth H′ H, and Op_1 Op_2 be the direction of two earthquake rays, then the *apparent* velocity is the distance p_1 p_2 divided by the time interval between the observations at the two points p_1 and p_2. During this interval the distance travelled by the wave within the earth has been sp_2.

The *true* velocity which may be called V is that with which it travels within the earth, as, for example, between the centrum and the epicentre. To show the relationship between these two velocities it is assumed that the true velocity is constant. On this assumption if O is a centrum, wave fronts may be represented by circles of coseismals, the distances apart of alternate members of which are equal and represent the distance travelled in unit time, which for convenience may be taken at one second. The true velocity V is therefore equal to sp_2, while the apparent velocity recorded on the surface is p_1 p_2. From the construction $sp_2 = p_1\ p_2 \sin \theta$, or $V = v \sin \theta$.

Fig. 16.



From this it follows that for points near to the epicentre C, the apparent velocity is very much greater than the true velocity, while between points at some distance from C the two velocities tend to become equal to each other. The law of this decrease in the apparent velocity is shown geometrically by drawing Seebach's hyperbola, which runs from C through a series of ordinates the lengths of which are equal to the differences between the time at which C was shaken and p_1 p_2, &c., were disturbed. The asymptote to this curve intersects the seismic vertical at the origin, and therefore if we are satisfied with the hypothesis, having given a number of time observations and knowing the position of the epicentre, the method may be used for determining the depth of a seismic focus.

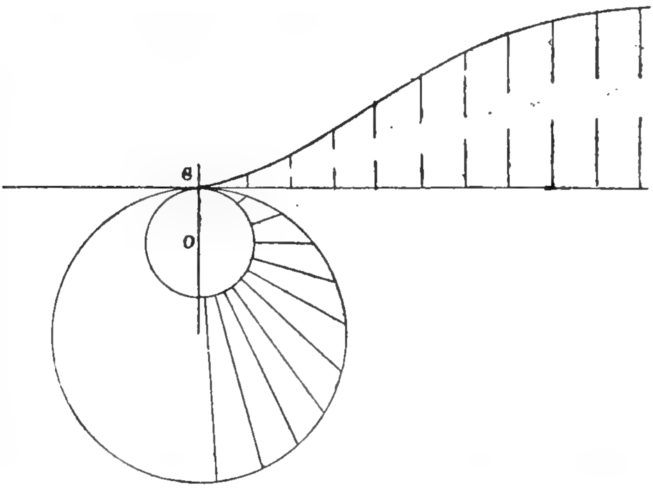
This hypothesis indicates why a disturbance should apparently be propagated with a high velocity near to its epicentre, but that this rapidly approaches a constant value.

2. *Hypothesis of Schmidt.*

As pointed out by Dr. A. Schmidt, directly we deal with an earthquake which has been propagated over a great distance it is necessary when constructing the velocity curve to take into consideration the curvature of the earth.

This curve (fig. 17), which has lost its hyperbolic character, shows by the convexity of its upper part that after a decrease in velocity in the epicentral regions at great distances the velocity again increases to become infinite. Dr. Schmidt has likewise shown that actual observations which have been made upon earthquakes are best satisfied by a velocity curve drawn on the supposition that the actual velocity within the earth

FIG. 17.

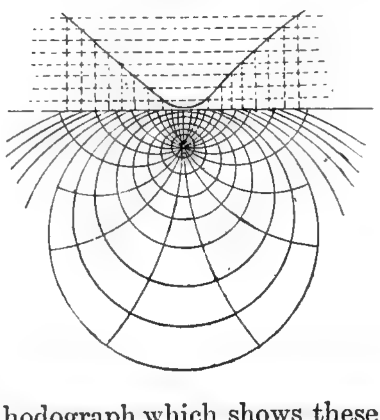


is not a constant, but varies with a change in elasticity and density of the rocks through which the waves are propagated.

As we descend in depth on account of an increasing temperature it is probable that with other changes there is a change in the elastic moduli of rocks. This being admitted, it then follows that a series of waves starting from a centrum would be propagated at a greater rate downwards than upwards towards the surface, while the normals to such a series of waves would by refraction gradually be bent upwards.

As illustrative of what would occur under the supposed conditions, Dr. Schmidt gives a diagram like fig. 18, in which coseismals have been drawn, on the assumption that the velocity has increased proportionately with the depth. In this case the earthquake rays which are perpendicular to successive coseismals are by refraction turned upwards, and no longer radiate in straight lines. The coseismals meet the surface at intervals, which first decrease from the epicentre and then increase, indicating a decrease and then an increase in the apparent velocity. The value for v is never less than the velocity at the centre, but after rapidly decreasing until it equals this value, it again increases. The velocity curve or earthquake hodograph which shows these changes is drawn through points determined as they were determined for Seebach's hyperbola. If there is an increase in the velocity of propagation of earth waves or in the quantity ϵ/ρ as we descend beneath the surface, whether we take the centrum near to the surface or at a great

FIG. 18.



depth, the resulting hodograph retains its character. Although the evidence that there is an increase in the velocity of propagation of waves as we trace them beneath the surface is by no means so complete as might be desired (see p. 161), Dr. Schmidt compares the advantages which the curvilinear propagation presents over that of the rectilinear transmission employed by Seebach.

It will be observed that in fig. 18 there is a great concentration of earthquake rays in the epifocal region which would correspond to the destruction which is so noticeable in such districts, while with rectilinear radiation the absence of such concentration is not in accord with the results of experience. Although both hypotheses agree in showing a higher apparent velocity near to the epicentre, in Seebach's hyperbola an identical limit is reached for the apparent horizontal velocity for all earthquakes, while Schmidt's modification of the laws shows that the apparent velocity on the surface cannot be less than that between the focus and the first coseismal, with which it varies. From this it follows that for limited areas the latter method admits the possibility of very high velocities resulting from earthquakes originating at reasonable depths. With rectilinear propagation on the contrary, to obtain such high velocities as have been observed, it is necessary that origins should be situated at enormous depths.

Should a disturbance originate near the surface, Schmidt's hodograph consists of two symmetrical concave branches which meet in an angle at the centre, indicating that the velocity increases from the epicentre outwards.

After indicating the above and other advantages presented by the hodograph over the hyperbola as representing the velocity with which earth waves are apparently propagated, Dr. Schmidt takes a number of earthquakes for which good time observations have been obtained and plots the resulting curves. These which refer to earthquakes felt over moderate areas show the characteristic inflexion point denoting an increased velocity in the outer portion of the disturbed tract.

The following are examples of his results :—

Middle Germany, March 6, 1872.—Longest wave path 400 km. Here the hodograph is distinct in character with a point of inflexion at about 11 miles from its vertex, having a slope indicating a velocity of 2·5 miles per minute. At a distance of 36·7 miles the velocity is 15 miles per minute. The curve passes much more closely through the points representing time and distance than the hyperbola of Seebach. Possible depth, 5 to 10 miles. Mallet's method, dependent upon a single observation, gives 1·9 to 2·9 miles.

Herzogenrath, October 22, 1873.—Longest wave path 150 km. In this case the hodograph is practically concave, throughout its length indicating an origin near the surface. It is indicated over a radius of 17 miles. Possible depth is less than 3 km. By Seebach's method it may be from 0 to 14 km.

Swiss Earthquake, January 7, 1887.—Longest wave path, 150 km. The general character of this hodograph is like the last. At the point of inflexion the velocity is 170 m. per second, and at 150 km. it is 1,300 m. The depth of the centrum is from 1 to 6 km.

Charleston Earthquake, August 31, 1886.—Longest wave path, 1,500 km. Here the hodograph is nearly a straight line. The depth of the centrum may exceed 120 km.

In the case of the first three of these examples, their hodographic character may be due to the fact that observations were made in epifocal areas, within which disturbances radiating from a centrum were recorded; but in the last example this character has been lost, because most of the times which were noted probably refer to the arrival of a surface disturbance capable of being felt, and which might have been recorded by ordinary seismographs.

These latter records are therefore such that we could not expect them to conform with the hypothesis under consideration, and until a number of stations separated by long distances are provided with instruments capable of recording minute tremors which may go *through* the earth. Until these have been established, it would seem that the confirmation of the attractive theory put forward by Dr. Schmidt must remain in abeyance.

3. *A Suggestion that there are three Classes of Movement.*

The last hypothesis is one that takes into consideration three classes of movements which immediately round an epicentre are hopelessly confused. These are the truly elastic disturbances which from a focus reach the surface of the earth along rectilinear or curvilinear paths, forced displacements, and quasi-elastic waves, causing tumultuous movements in the centre of a megistoseismic area, and long undulatory elastic-gravity waves which are propagated over the surface of the earth.

The escape of energy is most pronounced along the paths of least resistance, that is round the seismic vertical to an epifocal area, and then radially over the surface of the globe. The rate of propagation of the surface waves seems to be about 2 or 3 km. per second, and it may be fairly constant. The minute tremors which have been observed at stations 6,000 miles distant from their originating cause, if they travelled through the superficial crust of the earth they did so at a rate of perhaps 12 km. per second, while if they were created on the passage, their velocity, which is increased, becomes more abnormal. Assuming that they came as condensational waves *through* the earth, then their velocity is reduced to 8 or 10 km. per second, a quantity which, as suggested by Dr. E. von Rebeur-Paschwitz, may possibly throw new light upon the nature of materials constituting the interior of our earth. At present the facts bearing upon this latter question are both few and imperfect. To confirm or dispel the important conclusions indicated by the few facts at our disposal, it would seem desirable that investigations should be extended in such a manner that the results obtained by different observers would be comparable. With a set of stations situated round the globe at intervals of 15° or 30° apart, provided with instruments similar in character, similarly installed and similarly worked, which are capable of recording not simply small changes in level but also minute vibrations, we might easily extend our present knowledge, not simply respecting the propagation of surface undulations, but possibly of motion transmitted through the rigid globe. An indication of the latter phenomenon would be an enormous increase in the apparent velocity of a disturbance as it approached the antipodes of its origin, while the concentration of energy in such a region would suggest internal refraction.

Other phenomena which might be recorded would be the diurnal and longer period wanderings of the instruments, local earthquakes and earth tremors. The latter, although important in themselves, because they so often eclipse the effects of earthquakes, should, by proper instalment of the instruments, be as far as possible minimised.

(*e*) *Conclusions.*

If we except the curious results respecting the velocity of propagation of motion which we might expect to find, and which apparently exists in an epifocal area, the phenomenon of greatest interest, the study of which may lead us to important conclusions respecting the physical constitution of the interior of our globe, are the so-called *preliminary tremors* of earthquakes which are often continued as superimposed serrations on the quasi-elastic motions. In Japan these have been recorded and studied for the last 15 years, but it has only been within the last year or two that their appearance has been recognised in Europe.

All that I know about these latter records is what I learn by letters from Dr. E. von Rebeur-Paschwitz, and what I have seen in the publications of Dr. Agamennone and other Italian observers, and the conclusion is that these tremors are the reappearance of a phenomenon which has for so many years puzzled seismologists in Japan. If this is so, and if they really possess the abnormally high velocities attributed to them, seismologists may be on the verge of probing our earth to depths greater than it was thought probable that the study of earthquakes could possibly lead. Although something farther may yet be learned by studying the elastic gravitational surface disturbances, we know that whether they are recorded on paths of about 600 miles in length in Japan, or on paths of 6,000 miles in length between Japan and Europe, they travel at a rate of about 3 km. per second. All that is now required is to increase the accuracy of the observations by adopting such methods of noting the arrival of these disturbances that the records at each station refer to the same phase of motion.

Before the short list below was completed, I unfortunately lost my library and everything else by fire. It is therefore possible that some of my quotations may be incomplete and perhaps inaccurate. Such writings as have been referred to, so far as I am able to give them, are as follows :—

References.

Dr. A. Schmidt (Stuttgart).	Wellenbewegung und Erdbeben. 'Jahreshefte des Vereins für vaterl. Naturkunde in Württ.,' 1888.
" " . .	Untersuchungen über zwei neuere Erdbeben, das Schweizerische vom 7. Januar 1889 und das Nord-Amerikanische vom 31. August 1886. *Ibid.*, 1890.
P. Tacchini . . .	Terremoto calabro-messinese del 16 Novembre 1894. 'Reale Accademia dei Lincei,' vol. 3, p. 275.
" . . .	Sulla registrazione a Roma del terremoto calabro-messinese del 16 Novembre 1894. *Ibid.*, p. 365.
Dott. A. Cancani . .	Sulla velocità di propagazione del terremoto di Constantinopoli del 10 Luglio 1894. *Ibid.*, p. 409.
" . . .	Sugli strumenti più adatti allo studio delle grandi ondulazione provenienti da centri sismici lontani. *Ibid.*, p. 551.
" . . .	Sulle ondulazioni provenienti da centri sismici lontani. 'Annali dell Officio Centrale di Meteorologia e Geodinamica,' vol. 15, part 1, 1893.
Dott. G. Agamennone .	Velocità di propagazione delle principali scosse di terremoto di Zante nel recente periodo sismico del 1893. 'Reale Accademia dei Lincei,' vol. 2, p. 392.

Dott. G. Agamennone .	Alcune considerazioni sulla velocità di propagazione delle principali scosse di terremoto di Zante nel 1893. *Ibid.*, vol. 3, p. 383.
" " .	Alcune considerazioni sui differenti metodi fino ad oggi adoperati nel calcolare la velocità di propagazione del terremoto andaluso del 25 Dicembre 1884. *Ibid.*, p. 303.
" " .	Velocità superficiale di propagazioni delle onde sismiche, in occasione della grande scossa di terremoto dell' Andalusia del 25 Dicembre 1884. *Ibid.*, p. 317.
" " .	Sulla variazione della velocità di propagazione dei terremoti, attribuita alle onde transversali e longitudinali. *Ibid.*, p. 401.
Robert Mallet . .	Report on the Facts of Earthquake Phenomena. 'British Association Reports,' 1851.
" . . .	Report of the Experiments made at Holyhead, &c. *Ibid.*, 1861.
William Hopkins . .	Report on the Geological Theories of Elevation and Earthquakes. *Ibid.*, 1847.
Prof. Simon Newcomb and Capt. Dutton, C.E.	The Speed of Propagation of the Charleston Earthquake. 'Am. Journ. of Science,' vol. 35, January, 1888. Also other publications lost by fire.
F. Fouqué et Michel Lévy	Expériences sur la vitesse de propagation des secousses dans les sols divers. 'L'Académie des Sciences de l'Institut de France.' Tome 30.
General H. L. Abbot .	On the Velocity of Transmission of Earth Waves. 'Am. Journ. of Science and Arts,' vol. 15, March, 1878. Also other publications lost by fire.
J. Milne	Seismic Experiments. 'Trans. Seis. Soc.,' vol. 8.
"	On a Seismic Survey made in Tokio 1884–5. *Ibid.*, vol. 10.
Dr. C. G. Knott . .	Earthquakes and Earthquake Sounds as illustrating the General Theory of Vibrations. *Ibid.*, vol. 12.
Dr. E. von Rebeur-Paschwitz.	Many papers lost by fire.

V. Miscellaneous Notes relating to Large Earthquakes, &c.

1. *Large Earthquakes.*—During the past twelve months Japan has been visited by several destructive earthquakes, seismographic records of which are given in the list of shocks recorded by the Gray-Milne seismograph in Tokio. The velocities with which certain of these disturbances were propagated in Japan will be found in the fourth section of this report. At least three of the shocks were recorded in Europe, and to determine the velocities with which they were propagated diagrams and notes relating to observations made in Japan have been forwarded to Dr. E. von Rebeur-Paschwitz and Dr. P. Tacchini. The most notable disturbances were as follows.

June 20, 1894. Reference was made to this shock in the report for 1894. In Tokio it was felt very severely, destruction being equally great amongst foreign-built brick buildings on the high ground, and amongst similar structures in the foreign concession on the low ground. An excellent diagram, obtained from a seismograph without multiplication, has been published in the 'Journal of the College of Science' (Imperial University of Japan). The after shocks were extremely few in number.

October 22, 1894, 5.20 P.M. This shock, which created great destruction within an area not more than thirty miles in diameter round Shonai on the N.W. coast of the main island, does not appear to have been recorded by the Gray-Milne seismograph in Tokio.

The destruction it occasioned in the vicinity of its origin was enormous. More than 300 people lost their lives, while in some respects the country was more fissured and broken up than it was around Gifu in 1891, at which time nearly the whole of Japan was sensibly shaken. Sand hills or dunes, which have a breadth of 3,000 to 4,000 feet at their base, were fissured and sunk along their crests for a breadth of between 200 and 300 feet, and these openings extended for several miles. Fissures of great length were formed in the plains, whilst water and sand were shot upwards, and ring-like craterlets produced. One of the most curious phenomena was the filling up of wells with sand, and the shooting upwards for a height of several feet of their wooden linings. The after shocks were few in number.

January 18, 1895. At 10.48 P.M. on this date Tokio was again severely disturbed, and from the feelings of the inhabitants it was difficult to say whether the movement was more or less severe than that of June. The fact that many buildings which escaped the latter shock were on this occasion more or less shattered suggests the idea that the distribution of movement throughout the city was somewhat different.

The origin of the disturbance was apparently from 60 to 100 miles to the north or north-east of Tokio, and from this centre the preliminary tremors recorded by a seismograph outraced the main shock by 6 or 8 seconds. Had the writing pointer of the seismograph recorded its movements photographically, it is likely that this interval would have been increased. It will be of great importance to determine the interval between the preliminary tremors and the elastic surface gravitational waves for this shock as recorded in Europe.

Owing to the number of destructive earthquakes which occurred prior to the three here mentioned, so many observations have been accumulated that up to the present no time has been available for their analysis. The observations and notes collected by the writer relating to disturbances which have taken place during the last few years, which in themselves would have formed a voluminous report, were unfortunately destroyed by a fire referred to in the next paragraph.

2. *The Destruction of Books and Pamphlets relating to Seismology.*—It is with regret that I have to announce that on February 17 my house and observatory were entirely destroyed by fire. The losses consisted of collections of books, instruments, and other things accumulated during the last twenty years, the stock of the Transactions of the Seismological Society, which at the time were packed ready for shipment to Europe, and about 1,500 books and pamphlets relating to Earthquake and Volcanic Phenomena. All that I saved was the clockwork of a new seismograph and a bundle of photograms. The analysis of the latter forms the chief portion of this report.

3. *Alterations in the Construction of Chimneys.*—One effect of the recent earthquakes in Tokio has been to cause householders to rebuild the upper part of their chimneys with thin iron plate, while factory chimneys from 50 to 100 feet in height have for a length of 20 or 30 feet at about two-thirds up from their base been strengthened with a series of strong iron bands connected vertically by iron straps, it being observed that it

was usually near to this point that fracturing occurred.

4. *Experiments on the Vibration of Chimneys and Buildings.*—Shortly after my fire Professors Tanakadate, Mano, and other Members of the Earthquake Committee to which I am attached took diagrams of the natural vibrations of the brick chimney stack which was left standing after my fire. The chimney is 18 feet in height, and has a rectangular section of 3 feet 8 inches by 3 feet 1 inch and two flues. With a rope and a windlass, a deflection of the top of the stack of one inch and a half was obtained, when the rope was suddenly released The result was that the chimney vibrated for about 20 seconds, and a record of these vibrations was obtained upon a band of paper. One of the diagrams is reproduced, fig. 19. The period of motion has apparently varied with the range of swing; for example—

Range of Motion	1·25	in	Period	1·7	second.
,, ,,	·50	,,	,,	·85	,,
,, ,,	·10	,,	,,	·43	,,

When we remember that the greatest portion of the destruction occasioned by earthquakes is due to the fact that various portions of a building, in consequence of not synchronising in their movements, are mutually destructive, while solitary structures may be destroyed in consequence of the agreement between their natural period and that of an earthquake, it seems likely that observations like the one now described may lead to important rules being formulated for builders.

The next experiments will be on the vibration of wooden buildings.

5. *The Earth Waves of Earthquakes.*—On several occasions the apparatus described in the Report for 1893 has given diagrams showing the amount of tilting which accompanies certain earthquakes. The period of these angular displacements closely coincides with the periodicity of hori-

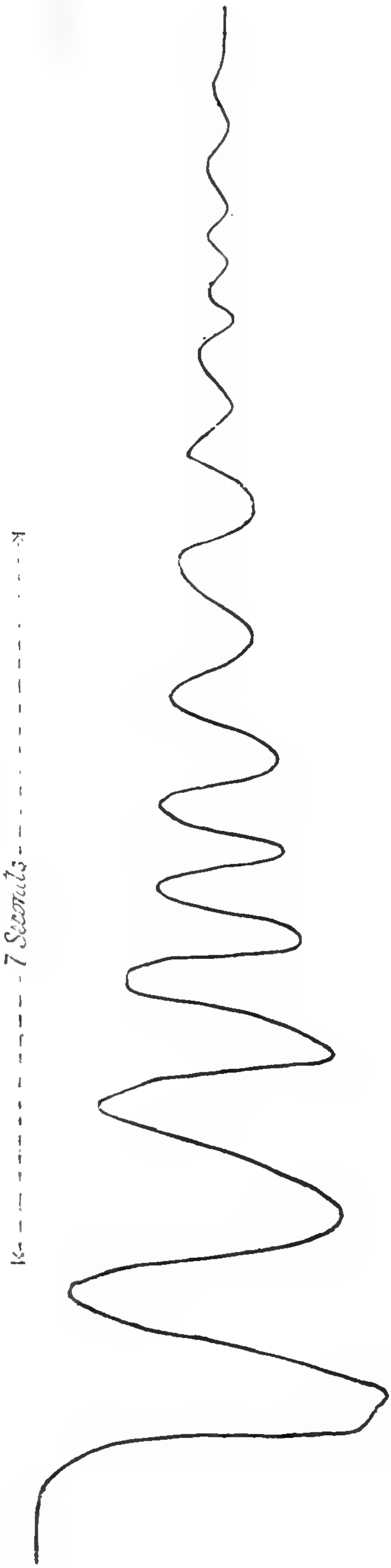


Fig. 19.

zontal displacement, and its amount has varied between one and three minutes of arc. The original instrument has unfortunately been destroyed by fire.

6. *Work at the Central Observatory under the Directorship of K. Kobayashi, Esq.*—Athough records from the 968 outside observing stations have accumulated at a quicker rate than that at which they can be tabulated for analysis, many important improvements have been made in the working of the central station. In one room all instruments intended for country stations are tested. These instruments are simplified types of the Gray-Milne seismograph. One test is for the time-recording clocks, another for the clock driving the recording surface, and a third for the multiplication of the horizontal and vertical seismographs. Although several types of spring clocks have been tested, their rates are far from being satisfactory. Cheap pendulum clocks give good rates, but they are generally disturbed at the time of an earthquake. In another room an exceedingly large seismograph, without multiplication, is arranged to record severe motions. In a third room, which is alive with the ticking of clocks and chronometers which are at stated intervals compared with time signals from the Astronomical Observatory, there are four seismographs and various types of contact makers. A glass disc recording surface, on which the pointers for vertical and horizontal motion rest, is continuously in motion. The recording surfaces of the other instruments are set in motion by the contact makers, after which time intervals are marked upon them from a break circuit chronometer. Mr. N. Outska, who is in charge of this department, finds that for horizontal and vertical contact makers having equal multiplication the former almost invariably closes its circuit before the latter.

APPENDIX.

On Causes producing Movements which may be mistaken for Earth Tremors.

The following note refers to observations and experiments made at a small observing station which has recently been established at Shide, in the Isle of Wight. I reached Shide on July 30, and on the following day a pit was excavated in a dry stable, about 3 ft. 6 in. in depth, down to the upper surface of the disintegrated chalk.

On August 6 and 7 a brick pier, 6 feet in height and 1 ft. 6 in. square, was built on a concrete bed to rise freely in the pit. The necessary wooden covering for this was completed at noon on the 16th, and that evening an extremely light horizontal pendulum like R was installed and set to work. This instrument, which I call T, gave a beautifully defined two-line diagram until the 21st, when the clock ceased to drive the film, which had become damp and sticky. This was clearly due to moisture from the drying column being confined in the casing which covered its upper part and the instrument. To overcome the difficulty I placed inside the case two trays, each about 6 in. by 3 in., of calcium chloride. Immediately after this the pendulum commenced to swing, its range sometimes reaching ½ inch. This continued until the 25th, when, suspecting that the cause might be due to air currents resulting from rapid desiccation, I removed the calcium chloride, and the movements ceased. I have repeated the experiment several times, with the result that when the calcium chloride is introduced, movements are produced, which in the developed film have the appearance of a violent tremor storm, and when it is taken away the diagram is a clear straight line. We have here a cause of air currents which has not yet received serious attention. Another cause of movement, which is easily verified by experiments on a very light pendulum beneath a glass covering, may be due to the unequal heating of the surrounding walls. If portions of the tremors which have been recorded are due to causes, such as these which act within the casings, then it is understood why extremely small and light pendulums have shown more movement than those which are comparatively large and heavy. After my last twenty installations, and those which preceded them, the horizontal pendulums might be arranged according to their sensibilities as follows. The most sensitive are those with booms from one quarter to 3 or 4 inches in length, the next are those like R, and the one at Shide T, where the boom is of reed or straw about 2 ft. 6 in. in length, following which are booms about 5 feet in length of bamboo like A, and lastly, as the least sensitive, are the somewhat shorter and comparatively heavier booms of brass or aluminium used at the remaining stations. The only exceptions in the last group were the instruments E and F in the underground chamber, which recorded tremors almost equally as large as A. In this chamber, although there was but little appreciable daily change in temperature, the ventilation was good, and therefore there may have been considerable changes in the hygrometric state of the atmosphere entering the covering cases, which were of wood resting upon a floor of asphalt. A difference in the rate at which moisture was absorbed or evaporated from the walls of this casing might possibly give rise to air currents. The five instruments in badly ventilated caves may have failed to show tremors, partly on account of their inertia, and partly perhaps because there was neither any sensible change in temperature nor in the dryness or wetness of the atmosphere. That tremors were practically absent from all the instruments on the surface, can only be attributed to their inertia, or to the fact that they were so well ventilated that no difference in temperature within their coverings was possible ; but as the huts and casings were similar to that of R, the most probable explanation is the former.

The most difficult things which require explanation respecting earth tremors, assuming them to result from air currents due to differences in temperature or desiccation within the walls that inclose the instruments, are the facts that tremors have in all cases but one been most pronounced between 6 A.M. and 9 A.M., and during the night, and that they accompany certain meteorological conditions already formulated.

Before attempting these explanations it would be advisable to compare the movements of two light pendulums standing on the same column, one having walls varying in character, and the other, if possible, in vacuum.

Earth Tremors.—Fifth Report of the Committee, consisting of Mr G. J. SYMONS, Mr. C. DAVISON (*Secretary*), Sir F. J. BRAMWELL, Professor G. H. DARWIN, Professor J. A. EWING, Dr. ISAAC ROBERTS, Mr. THOMAS GRAY, Sir JOHN EVANS, Professors J. PRESTWICH, E. HULL, G. A. LEBOUR, R. MELDOLA, *and* J. W. JUDD, Mr. M. WALTON BROWN, Mr. J. GLAISHER, Professor C. G. KNOTT, Professor J. H. POYNTING, Mr. HORACE DARWIN, *and* Dr. R. COPELAND, *appointed for the Investigation of Earth Tremors in this Country.* (*Drawn up by the Secretary.*)

SINCE their last Report was presented, the Committee have purchased two bifilar pendulums from the Cambridge Scientific Instrument Company. These instruments are similar in most respects to the pendulum with which experiments were made in 1893 (Report, 1893, pp. 291–303), but several improvements have been introduced in order to correct one or two defects which those experiments brought to light. The changes made are described in the Report of 1894 (pp. 145–146, 158–160), and a detailed account of the new instrument is given in 'Nature,' vol. l., 1894, pp. 246–249. Each pendulum is provided with a photographic recording apparatus. One of them has been erected on the old foundation in the cellar of the Secretary's house at Birmingham, but at too recent a date to allow any results to be included in this Report. It was intended that the second instrument should be placed in a building about three-quarters of a mile to the east of the first, but it was afterwards found that the construction of the foundation might endanger the stability of the walls. Arrangements are accordingly being made for the erection of this instrument on another site in the neighbourhood of the former, and it is hoped that a comparison of the records of both may be completed before the next meeting of the Association. The second pendulum will then be available for use elsewhere.

The Committee recommend that they be reappointed, with the addition of Mr. G. F. Deacon.

APPENDIX.

Note on the History of the Horizontal and Bifilar Pendulums. *By* C. DAVISON.

In previous Reports of this Committee, as well as in those of the Committee on the Lunar Disturbance of Gravity (1881–82), reference is made to the history of the horizontal and bifilar pendulums. A recent work by Mr. Claudius Kennedy [1] contains an interesting chapter on this subject, and gives some additional facts which it seems desirable to embody in this note.

[1] *A Few Chapters in Astronomy* (London, 1894), pp. 93–103.

In the following bibliography, the first date is that of the year in which, so far as known, the instrument was originally constructed.

1. 1832. L. Hengeller : 'Phil. Mag.,' vol. xlvi., 1873, pp. 412–416.
2. 1851. A. Gerard : 'Edinburgh, New Phil. Journ.,' vol. lv., 1853, pp. 14–16 ; Kennedy, pp. 94–95.
3. 1862. Perrot : 'Paris, Acad. Sci. Compt. Rend.,' vol. liv., 1862, pp. 728–729, 851–852.
4. 1869. Rev. M. H. Close : Barrett and Brown's 'Practical Physics,' 1892, p. 241 ; Kennedy, p. 96.
5. 1869. F. Zöllner : 'Phil. Mag.,' vol. xliii., 1872, pp. 491–496.
6. 1871. C. Delaunay : 'Paris, Acad. Sci. Compt. Rend.,' vol. xcvii., 1883, p. 230.
7. 1879. Lord Kelvin : 1880–81, G. H. and H. Darwin : 'Brit. Assoc. Rep.,' 1881, pp. 93–112.
8. 1887–88. E. von Rebeur-Paschwitz : 'Nova Acta der ksl. Leop. Carol. Deutschen Akademie der Naturforscher,' Bd. lx., 1892, pp. 1–216 ; 'Brit. Assoc. Rep.,' 1893, pp. 303–309.
9. 1892. J. Milne : 'Brit. Assoc. Rep.,' 1892, pp. 107–109 ; 'Fed. Inst. Mining Eng. Trans.,' 1893, pp. 6–7 ; 'Seismol. Journ.,' vol. i. 1893, pp. 88–90.
10. 1893. H. Darwin : 'Brit. Assoc. Rep.,' 1893, pp. 291–299 ; 1894, pp. 145–146, 158–160 ; 'Nature,' vol. l., 1894, pp. 246–249 ; 'Seismol. Journ.,' vol. iii., 1894, pp. 61–63.

In every case, I believe, except those numbered 8 and 10, the principle of the instrument was discovered independently. The horizontal pendulum has also been designed as a time-recorder for small disturbances by Professor J. Milne (Japan, 'Seismol. Soc. Trans.,' vol. iii., 1881, pp. 61–62 ; 'Nature,' vol. xlii., 1890, p. 347) ; Professor T. C. Mendenhall ('Amer. Journ. Sci.,' vol. xxxv., 1888, p. 105) ; and Professor G. Grablovitz ('Boll. della Soc. Seismol. Ital.,' vol. i., 1895, pp. 12–17).

All the different forms of horizontal and bifilar pendulums agree in one respect : the vertical distance between their points of support is very great compared with the horizontal distance between them. In principle they merely differ in the method of suspension ; and, according to this method, they may be grouped in the following three classes :—

1. The pendulum in which the rod or mirror is suspended by two wires. These may be again subdivided : (*a*) The pendulums of Close and H. Darwin, and practically also of Delaunay, and Lord Kelvin and the Darwins, in which the centre of gravity of the rod or mirror lies between the two points of attachment of the suspending wires. (*b*) The pendulums of Hengeller, Perrot, and Zöllner, in which it lies outside them.

2. The pendulums of Gerard and Milne, on which the rod is supported by one wire and on one steel point.

3. The pendulum of von Rebeur-Paschwitz, which is supported on two steel points.[1]

[1] In this class should be included Professor Ewing's horizontal pendulum seismograph, which, though designed for a different purpose, also records slow tilts of the ground (*Encycl. Brit.* vol. xxi. p. 628).

Meteorological Observations on Ben Nevis.—Report of the Committee, consisting of Lord McLaren (*Chairman*), Professor A. Crum Brown (*Secretary*), Dr. John Murray, Dr. Alexander Buchan, Hon. Ralph Abercrombie, *and* Professor R. Copeland. (*Drawn up by* Dr. Buchan.)

The Committee was appointed, as in former years, for the purpose of co-operating with the Scottish Meteorological Society in making Meteorological Observations on Ben Nevis.

The hourly eye observations by night as well as by day have been made uninterruptedly by Mr. Omond and his assistants during the year at the Ben Nevis Observatory; and the continuous registrations and other observations have been carried on at the Low Level Observatory at Fort William with the same fulness of detail as during the previous four years.

The Directors of the Observatories tender their cordial thanks to Messrs. C. M. Stewart, B.Sc., A. D. Russell, and C. T. R. Wilson for valuable assistance rendered as volunteer observers during the summer months for about six weeks each, thus giving greater relief to the members of the regular observing staff.

For the year 1894, Table I. shows the monthly mean and extreme pressures and temperatures, hours of sunshine, amounts of rainfall, number of fair days and of days when the amount exceeded one inch, the number of hours of bright sunshine; and this year for the first time the mean rainband (scale 0–8) at both Observatories, and the mean hourly velocity of the wind in miles at the top of the mountain. The mean barometric pressures at the Low Level Observatory are reduced to 32° and sea level, while those at the top of the Ben are reduced to 32° only.

Table I.

1894	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						Mean Pressure in Inches.							
Ben Nevis Observatory	24·980	25·086	25·192	25·286	25·357	25·450	25·369	25·339	25·665	25·357	25·181	25·232	25·291
Fort William	29·595	29·697	29·764	29·844	29·951	29·960	29·820	29·823	30·232	29·915	39·716	29·828	29·845
Differences	4·615	4·611	4·572	4·558	4·594	4·510	4·451	4·484	4·567	4·558	4·535	4·596	4·554
						Mean Temperatures.							
Ben Nevis Observatory	21°·7	24°·0	28°·2	31°·1	29°·1	38°·2	43°·3	39°·2	37°·3	32°·7	31°·3	27°·6	32°·0
Fort William	39·3	40·3	42·9	48·4	46·9	54·8	58·9	55·2	51·0	45·6	46·7	41·1	47·6
Differences	17·6	16·3	14·7	17·3	17·8	16·6	15·6	16·0	13·7	12·9	15·4	13·5	15·6
						Extremes of Temperature, Maxima.							
Ben Nevis Observatory	35°·4	36°·2	41°·2	40°·8	45°·1	63°·5	62°·9	53°·9	55°·1	55°·5	42°·6	41°·0	63°·5
Fort William	53·5	52·0	63·1	62·6	61·1	78·2	81·5	65·5	63·6	59·9	60·0	56·2	81·5
Differences	18·1	15·8	21·9	21·8	16·0	14·7	18·6	11·6	8·5	4·4	17·4	15·2	18·0
						Extremes of Temperature, Minima.							
Ben Nevis Observatory	0°·7	12°·3	17°·6	22°·8	16°·1	28°·3	32°·6	31°·0	26°·4	17°·1	20°·3	11°·2	0°·7
Fort William	20·8	21·5	28·7	33·9	31·7	38·0	47·3	42·6	37·3	24·5	31·7	24·4	20·8
Differences	20·1	9·2	11·1	11·1	15·6	9·7	14·7	11·6	10·9	7·4	11·4	13·2	20·1

TABLE I.—*continued.*

1894	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
						Rainfall in Inches.							
Ben Nevis Observatory	15·96	33·55	14·58	3·50	6·66	8·33	11·35	17·70	1·32	4·68	17·40	14·93	149·96
Fort William	11·79	13·62	9·36	1·37	3·78	3·13	5·70	7·72	0·24	2·06	11·62	8·78	79·17
Differences .	4·17	19·84	5·22	2·13	2·88	5·20	5·65	9·98	1·08	2·62	5·78	6·15	70·79
						Number of Days 1 in. or more fell.							
Ben Nevis Observatory	4	11	6	1	0	3	4	6	0	1	5	5	46
Fort William	3	3	3	0	0	1	1	1	0	0	2	2	16
Differences .	1	8	3	1	0	2	3	5	0	1	3	3	30
						Number of Days of no Rain.							
Ben Nevis Observatory	4	2	14	18	10	12	9	7	21	13	3	6	119
Fort William	6	3	14	20	12	19	12	13	25	21	5	7	157
Differences .	2	1	0	2	2	7	3	6	4	8	2	1	38
						Mean Rainband (scale 0–8).							
Ben Nevis Observatory	2·0	2·7	1·9	1·9	1·8	2·4	2·5	2·3	1·5	1·9	2·1	1·4	2·0
Fort William	3·0	4·4	3·3	3·6	3·8	4·8	5·3	5·2	3·6	3·6	4·4	3·0	4·0
Differences .	1·0	1·7	1·4	1·7	2·0	2·4	2·8	2·9	2·1	1·7	2·3	1·6	2·0
						Number of Hours of Bright Sunshine.							
Ben Nevis Observatory	3	9	101	82	78	117	115	45	126	91	15	28	810
Fort William	16	20	132	165	171	170	143	76	147	91	13	16	1,160
Differences .	13	11	31	83	93	53	28	31	21	0	−2	−12	350
						Mean Hourly Velocity of Wind in Miles.							
Ben Nevis Observatory	26	19	18	19	11	10	12	11	11	15	18	18	15·7
						Percentage of Cloud.							
Ben Nevis Observatory	95	96	69	80	85	77	80	89	58	69	91	84	81
Fort William	75	80	54	60	76	73	73	72	56	66	84	79	71
Differences .	20	16	15	20	9	4	7	17	2	3	7	5	10

At Fort William the mean temperature of the whole year was 47°·6, or 0°·8 greater than the mean of previous years, being the excess above the mean at western stations in Scotland from Ayrshire to Ross-shire. The mean temperature at the top of Ben Nevis was 32°·0, or 0°·9 above the mean for the same years, being thus nearly the same excess as at the lower Observatory.

The lowest mean monthly temperature at Fort William was 39°·3 in January, being 0°·7 above the mean; and at the top of the Ben 21°·7 in January, which is 2°·1 under the mean. This gives an unwonted large difference of temperature between the Observatories for January, which was occasioned by a comparative absence of anticyclonic weather and the relatively low temperature accompanying at the upper station, and the singular want of sunshine, there being registered for the whole month only three hours of sunshine. On the other hand, anticyclonic weather was of frequent occurrence in September, October, and December; and accordingly in these months sunshine was large, being absolutely the highest hitherto recorded in September and October, and having been only exceeded in December. It will be also observed that during these months the difference of temperature between the two Observatories was much less than usual, owing to the higher temperature of the anticyclones at the top of the Ben. The highest monthly mean temperature at Fort William was 58°·9 in July, or 2°·2 above the mean; and at the top 43°·3 in the same month, or 3°·0 above the mean. The month of greatest excess above the average was November, whose mean temperature at Fort William was 46°·7, or 4°·1 above the mean, while at the top it was 31°·3 or 3°·2 above the mean. This great excess of temperature was about the same in all parts of Scotland, and was occasioned by an extraordinary predominance of south-westerly wind, which exceeded any observed in November during the past forty years. The sunshine was markedly deficient, and hence temperature at the top was relatively lower than at Fort William. The following show the deviations of the monthly results from their respective means:—

TABLE II.

	Top of Ben Nevis	Fort William
	°	°
January	−2·0	0·7
February	0·6	1·8
March	4·5	3·1
April	3·4	3·4
May	−3·7	−2·6
June	−0·7	−0·5
July	3·0	2·2
August	−0·6	−1·1
September	−0·2	−1·9
October	1·1	−1·4
November	3·2	4·1
December	2·5	1·7
Year	0·9	0·8

The maximum temperature at the top was 63°·5 on June 30, and 81°·5 at Fort William on July 1. The minimum temperature at the top was 0°·7 on January 6, and at Fort William 20°·8 on January 6.

The above minimum temperature 0°·7 is absolutely the lowest yet observed on the top of Ben Nevis. The conditions under which it occurred are seen in the following extract from the day's observations:—

TABLE III.—*Weather accompanying Low Temperature of January 6, 1894.*

Hour of Observation.	3 A.M.	4 A.M.	5 A.M.	6 A.M.	7 A.M.	8 A.M.	9 A.M.	10 A.M.	11 A.M.	Noon	1 P.M.
Barometer, at 32°, 24 in.+	·877	·863	·827	·804	·784	·782	·785	·807	·829	·834	·840
Dry Bulb	13·0	13·3	11·2	9·0	5·2	0·7	1·0	2·0	3·4	3·9	4·2
Wet Bulb	12·8	13·1	11·0	8·8	5·0	0·4	0·9	1·8	3·1	3·8	4·0
Wind Direction	E.	E.	E.byS.	E.	E.S.E.	E.S.E.	E.S.E.	S.E.by E.	S.E.	S.E.	S.E.by E.
Do. miles per hour	25	25	38	38	43	38	38	30	29	29	29
Melted Snow in inch.	·008	—	·005	·003	·007	—	·002	·004	·004	·009	·006
Cloud	fog	fog	fog	fog	fog	fog	fog	fog	fog	fog	fog

This low minimum temperature occurred at the same time as the lowest barometric reading of a small satellite cyclone passing over the British Islands (see Daily Weather Reports). As the centre of the disturbance advanced, temperature very rapidly fell, and thereafter rose steadily, but more slowly than it had fallen, and the easterly winds acquired a little southing. The wind was high throughout, attaining at 7 A.M. a velocity at the rate of 43 miles an hour, accompanied by constant fog and showers of snow. It is this type of weather, a temperature approaching zero, near the point of saturation, and fog drifted onward with very high wind, which is the most disagreeable and prejudicial to health of all weather encountered at this high elevation. It may also be noted that the dip in the temperature was coincident with the dip in the barometric pressure.

The registrations of the sunshine recorder on the top show 810 hours out of a possible 4,470 hours, being 130 hours more than in 1893. This equals 18 per cent. of the possible sunshine. The maximum was 126 hours in September, which is higher than any previously recorded September; and the minimum 3 hours in January, being the lowest yet recorded in this month. At Fort William the number for the year was 1,160 hours, being 95 hours in excess of the previous year. As the number of hours of possible sunshine at Fort William is, owing to the surrounding hills, only 3,497 hours, the sunshine of 1894 here was 33 per cent. of the possible number.

TABLE IV.—*Lowest Hygrometric Observations during each Month of* 1894.

—	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Dry Bulb	25·8°	20·4°	24·3°	29·4°	30·6°	40·0°	62·9°	52·0°	49·6°	5[illegible]·0°	42·0°	22·0°
Wet Bulb	23·8	14·4	18·8	24·2	23·9	29·2	48·1	36·8	31·8	34·[illegible]	30·3	16·9
Dew-point	13·5	−27·6	−13·1	6·5	4·5	15·3	36·3	21·6	12·2	16·4	15·9	−16·8
Elastic Force	·080	·010	·023	·058	·053	·087	·214	·116	·075	·091	·089	·019
Relative Humidity Saturation=100	57	9	18	36	31	35	37	39	21	25	34	16

Of these lowest monthly humidities the lowest (9) occurred at 1 P.M. on February 14, at which hour the dew-point was −27·6° and the elastic force 0·010 inch. The previous month (January) presents a striking contrast to this, the lowest humidity being no lower than 57. It is also to be noted that during the eight months from April to November the dew-point on no occasion fell to zero.

At the top the percentage of cloud covering the sky was 81, being 3 less than the average of previous years. The variation during the months was great, being above 90 per cent. in January, February, and November; while, on the other hand, the minimum was 58 per cent. in September and 69 per cent. in October. At Fort William the annual mean was 72 per cent., the maximum being 84 per cent. in November, and the minimum 54 per cent. in March.

The mean rainband (scale 0–8) observations at the top was 2·0 for the year, the maximum being 2·7 in February and the minimum 1·5 in September, when the weather was eminently anticyclonic. At Fort William the means were for the year 4·0, the maximum 5·3 in July, and the minimum 3·0 in January and December.

The mean hourly velocity of the wind at the top was 16 miles, the monthly mean maximum being 26 miles in January, and the minimum 10 miles in June. For the five months from May to September the mean was 11 miles per hour, but for the six months from November to April the mean was 20 miles per hour. The relations here indicated among the seasons substantially hold good year by year.

The rainfall for the year at the top was 149·96 inches, being 3·63 inches above the average. At Fort William the amount was 79·17 inches, which is 4·07 inches above the average. The maximum monthly rainfall at the top was 33·55 inches in February, and the minimum 1·32 inch in September. At Fort William the maximum monthly fall was 13·62 inches in February, and the minimum fall 0·24 inch in September. The above are the smallest monthly amounts yet recorded at either of the Observatories, and the maxima are higher than any hitherto recorded for February.

These two months were a strong contrast to each other. In February, cyclone succeeded cyclone in swift succession to each other accompanied with heavy and destructive gales, deluges of rain, and heavy snowfalls; whereas September was for much the greater part of the month under the influence of anticyclones, accompanied with clear sky, dry and well-nigh rainless weather. At the top of the Ben 6·67 inches of rain fell on February 6, being, except on October 3, 1890, the greatest daily fall on the records of the Observatory.

At the top the rain fell on 246 days, and at Fort William on 208 days, being respectively 14 and 30 days under their averages. The maximum number of days on which rain fell at the top and at Fort William was 27 days in January, and the minimum number 9 days at the top and 5 at Fort William in September.

During the year the number of days on which an inch of rain was exceeded was 46 days on Ben Nevis and at Fort William 16 days. In February the numbers were 11 days and 3 days respectively.

Auroras are reported to have been observed on the following dates:— February 13, 25; March 24, 25, 30, 31; April 28; August 23, 31; September 1, 2, 27, 30; October 2, 4, 5, 26, 27, 30, 31; November 23, 24, 26; December 1.

St. Elmo's Fire was seen on January 25; February 4, 9; March, 3, 5, 6, 9, 12; May 29, 30; June 18; July 7, 21; November 8, 15.

The Zodiacal Light was observed on March 24, 25, 26.

Thunder and lightning reported on February 3, 8; July 6, 7, 21; August 15; September 17; lightning only on January 29, February 4, 25.

Almost daily during the last week of February there were strong earth-currents in the telegraph cable between the base and summit of the hill.

At Fort William the mean atmospheric pressure at 32° and sea-level was 29·845 inches, and at the top 25·291 inches, the difference being thus 4·554 inches, being only very slightly above their averages. At the top the highest pressure during the year was 25·992 inches in June, and the lowest 23·742 inches in December, the difference being 2·250 inches, a rather large difference.

Mr. A. J. Herbertson has made further progress in carrying on, at the two Observatories and in the south of France, the research on the hygrometry of the atmosphere referred to in last report. The work is now in an advanced stage of preparation, and the results will shortly be published in the *Transactions* of the Royal Society of Edinburgh and in the *Journal* of the Scottish Meteorological Society.

Much work has been done in the offices in Edinburgh and Fort William in recopying, on separate daily sheets, the hourly observations of the two Observatories, in connection with a strictly scientific examination of the two sets of observations in their bearings on the meteorology of north-western Europe.

This important research was begun by Dr. Buchan in spring last, and it has since occupied any time that has been available after the discharge of his official duties. The subject has been divided into several parts, and each is treated separately by itself, in its relations with the other observations more or less closely connected with it. The following are the selected divisions of the research: Cyclones; anticyclones; differences of temperature between the top and bottom of the mountain, much smaller than the normal difference, including inversions of temperature, when the temperature at the top is higher than that at Fort William; large differences of temperature, much exceeding the normal difference, particularly in their close connections with coming storms; great dryness of air at top, which occurs with anticyclones, and their intimate bearing on the movements of these important weather factors; marked differences of wind at top and bottom, both as regards direction and force, especially in their close relationship to the extent of the 'droop' of the barometric pressure likely to occur with the coming cyclone; relations of the observations above and below to the storms reported by the keepers of the Scottish Northern Lighthouses; conditions under which very diverse readings of the two barometers occur, as regards time of phases, and character of the fluctuations; and an examination of the whole observations with the reported rainfall at about a hundred stations selected from all parts of Scotland.

In these inquiries the weather maps of this and other European countries at the time are examined. The general method of treatment may be best shown by an example. Thus in dealing with cyclones, the following data are collected and entered in the respective columns of the sheet for cyclones, viz., position in Europe of the cyclone; position of the nearest anticyclone at the time, with its highest recorded barometer and place; the direction in which Ben Nevis is situated from the cyclone, whether N., N.E., E., &c.; distance of Ben Nevis from the centre of the cyclone in miles; temperatures at the Observatories; humidities at ditto, sunshine and cloud at ditto; barometer at Fort William, at sea level; lowest recorded barometer at centre of cyclone, and its position; wind at sea level from daily weather maps, and at top of mountain; and the lighthouses at which storms occurred.

It will be recognised that several of these points have been to some extent already adverted to in our previous reports; but what is now attempted to be done is an inquiry into their relations to each other. The unique character of the inquiry results from the fact that the High Level Observatory on Ben Nevis is situated right in the general path of the cyclones of north-western Europe, whereas the other high level observatories and stations of Europe that have been used in similar investigations are altogether outside that path. So far as it has gone, the inquiry already points to the result that there can be no doubt most important modifications will require to be made as to the theories of the cyclone more generally held by meteorologists at the present time.

It being felt that more assistance was required to expedite this work of discussion than it is in the power of the directors to give, application was made to the President and Council of the Royal Society for a grant of 100*l*. from the fund placed at their disposal by the Government Grant Committee. The application was granted, and the money will be applied in paying assistants for doing portions of the routine work of the offices in Edinburgh and Fort William, in order to give Dr. Buchan and Mr. Omond time for carrying on the inquiries sketched out above.

The examination of the Hourly Barometric Curves during fine, clear days and during cloudy days respectively, have been continued, on account of their very high value in connection with the work of the two Observatories. To our last report six tables were appended, giving the hourly values for each month for the top of the mountain for Fort William, and for Trieste, near the head of the Adriatic, for clear and cloudy days respectively.

During the year Mr. Omond has continued these most laborious calculations, so that your Committee are in a position to add four Tables to the above. The two new stations are Magdeburg, in Germany, selected because its comparatively dry climate forms an admirable contrast to the rather wet climates of Fort William and Trieste, and San José, situated in lat. 9°·56′ N., long. 84°·0 W., and at a height of 3,756 feet above the sea. As its height approximates to that of Ben Nevis, the observations made at this Observatory, which is situated only ten degrees from the equator, form an excellent comparison with those made at the top of Ben Nevis.

Tables V.–VIII. give the departures in thousandths of an inch from the daily means of the barometer at each hour of the day at Ben Nevis, Fort William, Trieste, Magdeburg, and San José, on fine or sunny days, and on cloudy or overcast days. In each case, three years have been taken, though not the same years at each station, the figures being 'bloxamed,' as in last report. San José is chiefly interesting as showing how a tropical station in a steady climate, where every reading of the barometer during the three years lay between 26·000 and 26·400 inches, with rain falling only at certain seasons, and then almost wholly confined to the afternoon hours, differs from the records of a temperature zone-station with a variable climate.

This is not the place to enter on any adequate discussion of the results, but it is of importance to point out that the characteristically low morning maximum, and very high evening maximum during cloudy days at Ben Nevis, Fort William, Trieste, and Magdeburg, in all seasons, do not occur at San José in similar weather. It is, however, different as regards the two daily minima at San José, the morning minimum being distinctly larger on cloudy than on sunny days, and the afternoon minimum less. There are also marked characteristics, in cloudy weather, of the barometric pressure at Fort William and Trieste, suggesting that in such weather the temperature of the atmosphere, taken as a whole, falls to a greater extent than when the sky is clear, and tension is consequently more reduced; but that the temperature of the lower strata of the atmosphere rises to a less extent than it does in sunny weather, when the surface of the earth is screened by clouds, resulting in a reduced ascending current from the heated ground.

TABLE V.—*Showing at Magdeburg the Mean Hourly Variation of Pressure, in thousandths of an inch, during fine or sunny days. The minus sign shows means under the average.*

Latitude	. . . . . .	52°·9 N.
Longitude	. . . . . .	11·37 E.
Height	. . . .	177 ft.

Hour	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1 A.M.	− 7	−11	−10	− 4	3	2	0	− 3	− 7	− 9	− 9	− 5	--
2 "	− 7	−11	−10	− 5	1	1	− 0	− 3	− 8	−11	−10	− 6	–
3 "	− 8	−10	− 9	− 4	1	2	− 1	− 3	− 8	−12	−12	− 9	− 6
4 "	−10	−11	− 9	− 3	2	5	2	− 2	− 7	−10	−12	−10	− 5
5 "	−10	− 8	− 5	1	6	9	5	1	− 4	− 6	− 9	−10	− 2
6 "	− 6	− 1	3	8	13	15	12	8	2	− 1	− 6	− 7	3
7 "	− 2	5	10	15	18	20	18	15	10	7	− 1	− 3	9
8 "	9	15	20	22	22	23	21	20	16	15	10	8	17
9 "	14	20	24	24	23	22	21	20	19	18	14	12	19
10 "	21	23	26	24	22	21	21	20	20	20	20	18	21
11 "	17	23	25	21	17	16	17	17	18	19	17	15	18
Noon	9	16	15	14	9	9	11	10	11	11	6	6	11
1 P.M.	− 0	7	11	6	2	2	3	3	4	3	1	− 4	3
2 "	− 7	− 0	1	− 3	− 7	− 6	− 4	− 6	− 4	− 4	− 5	−10	− 4
3 "	− 8	− 5	− 8	−12	−16	−14	−11	−13	−10	− 8	− 7	− 8	−10
4 "	− 7	− 8	−14	−19	−23	−20	−17	−17	−14	−11	− 8	− 7	−14
5 "	− 5	− 8	−15	−22	−27	−28	−24	−21	−14	− 9	− 4	− 3	−15
6 "	− 1	− 6	−13	−21	−31	−29	−26	−21	−11	− 4	2	1	−13
7 "	2	− 2	− 8	−15	−22	−26	−23	−16	− 6	− 0	5	4	− 9
8 "	5	− 1	− 3	− 8	−13	−18	−15	− 8	− 0	3	6	6	− 4
9 "	5	− 1	− 3	− 4	− 5	− 7	− 7	− 3	− 0	3	6	7	− 1
10 "	2	− 5	− 6	− 4	− 0	− 2	− 1	1	− 0	0	2	4	− 1
11 "	− 1	− 8	− 8	− 3	3	2	1	1	− 3	− 5	− 3	2	− 2
Midnight	− 5	−11	−11	− 3	2	2	0	− 2	− 8	−10	− 7	− 1	− 5

TABLE VI.—*Showing at Magdeburg the Mean Hourly Variation of Pressure, in thousandths of an inch, during cloudy days. The minus sign shows means under the average.*

Hour	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1 A.M.	6	9	9	3	6	10	16	14	10	9	5	6	9
2 "	6	7	6	− 1	1	4	9	7	4	4	4	5	5
3 "	3	2	− 0	− 7	− 3	− 1	5	− 0	− 4	− 4	− 1	3	− 1
4 "	− 1	− 3	− 5	− 8	− 3	− 1	2	− 6	−10	−11	− 6	− 2	− 4
5 "	− 4	− 6	− 7	− 7	− 1	1	1	− 8	−13	−14	−10	− 6	− 6
6 "	− 5	− 7	− 7	− 5	− 0	1	− 1	− 8	−14	−17	−13	− 7	− 7
7 "	− 4	− 5	− 4	− 0	5	4	1	− 6	− 9	−12	− 9	− 6	− 4
8 "	1	− 0	1	5	7	4	1	− 3	− 3	− 4	− 3	− 0	− 0
9 "	2	− 0	2	6	6	3	− 1	− 2	− 1	− 2	1	1	1
10 "	4	1	5	7	8	3	− 1	1	3	1	5	4	4
11 "	3	2	4	10	6	3	− 2	0	3	2	4	2	3
Noon	− 0	1	2	7	2	− 2	− 7	− 3	1	− 2	− 1	− 3	− 0
1 P.M.	− 9	− 6	− 3	3	− 2	− 5	−10	− 5	− 2	− 4	− 5	−10	− 5
2 "	−14	−11	− 8	− 1	− 5	− 7	−11	− 6	− 4	− 6	−10	−14	− 8
3 "	−14	−14	−13	− 7	−11	−11	−14	− 9	− 6	− 8	− 9	−13	−11
4 "	−11	−13	−14	−11	−15	−13	−15	− 9	− 7	− 7	− 6	− 9	−11
5 "	− 8	−11	−14	−13	−16	−16	−16	−11	− 7	− 4	− 2	− 5	−10
6 "	− 3	− 4	− 8	−10	−14	−13	−13	−10	− 4	1	2	− 1	− 6
7 "	1	1	− 1	− 4	− 6	− 8	− 8	− 5	1	6	5	3	− 1
8 "	6	6	5	2	0	− 2	− 1	4	8	11	8	8	5
9 "	8	9	9	6	7	8	9	12	12	15	10	9	10
10 "	11	12	12	8	10	12	15	15	13	15	11	11	12
11 "	12	14	14	8	10	14	18	18	14	15	11	12	13
Midnight	11	14	14	7	10	14	21	20	16	16	11	12	14

Table VII.—*Showing at San José the Mean Hourly Variation of Pressure, in thousandths of an inch, during fine or sunny days. The minus sign shows means under the average.*

Latitude . . . . . . 9° 56′ N.
Longitude . . . . . . 84° 0′ W.
Height . . . . . . 3,756 ft.

Hour	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1 A.M.	13	15	15	14	12	9	10	11	12	12	12	14	12
2 ,,	0	−1	−1	−1	−1	−2	0	1	1	1	1	3	0
3 ,,	−9	−10	−10	−11	−9	−11	−9	−10	−9	−9	−8	−7	−9
4 ,,	−13	−13	−15	−15	−13	−14	−12	−13	−12	−12	−12	−11	−13
5 ,,	−5	−6	−8	−9	−8	−11	−9	−10	−8	−7	−6	−3	−8
6 ,,	7	8	3	3	2	−2	−4	−4	−1	3	3	8	2
7 ,,	21	22	19	18	14	11	7	7	10	15	17	21	15
8 ,,	38	38	32	28	24	19	15	18	23	27	29	34	27
9 ,,	41	42	39	33	29	25	23	25	30	33	35	37	33
10 ,,	38	39	34	29	25	24	24	27	31	32	33	34	31
11 ,,	25	26	23	18	15	14	15	17	19	20	20	21	20
Noon	3	5	5	1	−1	0	2	4	2	−1	−3	−2	1
1 P.M.	−23	−20	−20	−21	−21	−16	−14	−15	−20	−25	−27	−27	−21
2 ,,	−42	−40	−39	−39	−37	−30	−27	−29	−36	−40	−42	−43	−37
3 ,,	−56	−55	−54	−52	−47	−39	−38	−42	−49	−51	−54	−56	−49
4 ,,	−56	−57	−57	−55	−56	−43	−42	−44	−49	−51	−54	−56	−51
5 ,,	−48	−52	−50	−47	−40	−32	−32	−33	−37	−38	−41	−46	−41
6 ,,	−31	−36	−34	−28	−21	−15	−15	−17	−19	−20	−21	−25	−24
7 ,,	−8	−13	−11	−6	−2	−0	−0	−2	−3	−3	−1	−4	−4
8 ,,	6	3	6	10	11	12	10	9	11	11	14	9	9
9 ,,	19	17	20	25	24	23	21	21	23	24	25	21	22
10 ,,	28	27	32	34	32	29	28	29	31	31	32	29	30
11 ,,	31	33	39	40	35	32	27	28	29	27	28	28	31
Midnight	23	30	30	31	26	22	20	22	22	20	19	20	23

Table VIII.—*Showing at San José the Mean Hourly Variation of Pressure, in thousandths of an inch, during cloudy days. The minus sign shows means below the average.*

Hour	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1 A.M.	10	9	9	10	10	9	10	10	13	11	11	9	10
2 ,,	−3	−5	−4	−7	−6	−5	−2	−2	0	−1	0	−3	−3
3 ,,	−14	−18	−17	−19	−16	−15	−11	−11	−10	−13	−11	−11	−14
4 ,,	−18	−21	−22	−24	−22	−20	−15	−16	−14	−16	−15	−18	−19
5 ,,	−11	−13	−15	−19	−20	−18	−14	−14	−12	−12	−10	−12	−14
6 ,,	−1	−1	−4	−6	−10	−9	−10	−8	−6	−4	−2	−1	−5
7 ,,	14	13	12	8	4	2	2	6	9	11	13	13	9
8 ,,	25	27	24	21	15	13	12	16	19	23	24	25	20
9 ,,	36	38	35	31	24	23	21	24	27	31	33	35	30
10 ,,	38	38	35	31	27	26	25	26	29	33	37	38	32
11 ,,	23	25	26	23	21	19	19	17	18	20	22	22	21
Noon	4	6	8	8	8	7	7	3	0	−2	−1	1	4
1 P.M.	−19	−13	−11	−12	−11	−9	−7	−11	−14	−22	−25	−22	−15
2 ,,	−36	−32	−28	−27	−25	−21	−19	−21	−29	−34	−35	−37	−29
3 ,,	−47	−45	−41	−40	−36	−33	−32	−33	−37	−40	−45	−48	−40
4 ,,	−48	−47	−44	−44	−41	−39	−39	−38	−41	−43	−47	−50	−43
5 ,,	−35	−36	−38	−38	−34	−31	−31	−31	−30	−31	−36	−35	−34
6 ,,	−22	−24	−25	−20	−15	−13	−15	−15	−17	−18	−21	−20	−19
7 ,,	−5	−7	−6	3	6	4	−4	−4	−4	−1	−2	−3	−2
8 ,,	7	6	6	10	12	11	7	8	9	12	11	11	9
9 ,,	20	18	18	25	26	23	19	19	20	23	24	25	22
10 ,,	29	28	29	34	33	29	27	27	29	30	32	33	30
11 ,,	27	28	31	34	35	30	28	26	29	28	29	28	29
Midnight	21	22	24	25	25	22	21	18	21	20	21	19	22

Experiments for improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Professor CAREY FOSTER (*Chairman*), Lord KELVIN, Lord RAYLEIGH, Professors AYRTON, J. PERRY, *and* W. G. ADAMS, Drs. O. J. LODGE, JOHN HOPKINSON, *and* A. MUIRHEAD, Messrs. W. H. PREECE *and* HERBERT TAYLOR, Professor J. D. EVERETT, Professor A. SCHUSTER, Dr. J. A. FLEMING, Professors G. F. FITZGERALD, G. CHRYSTAL, *and* J. J. THOMSON, Messrs. R. T. GLAZEBROOK (*Secretary*) *and* W. N. SHAW, Rev. T. C. FITZPATRICK, Dr. J. T. BOTTOMLEY, Professor J. VIRIAMU JONES, Dr. G. JOHNSTONE STONEY, Professor S. P. THOMPSON, Mr. G. FORBES, Mr. J. RENNIE, *and* Mr. E. H. GRIFFITHS.

THE work of testing resistance coils at the Cavendish Laboratory has been continued. A table of the coils tested is given.

Ohms.

No. of Coil		Resistance of Coil in Ohms	Temperature
Nalder, 4341 . . .	No. 422	·99849	11°·8
Nalder, 4650 . . .	No. 423	1000 (1 – ·00041)	15°
Elliott, 309 . . .	No. 424	·99902	13°·1
Elliott, 310 . . .	No. 425	·99915	13°·2
Elliott, 311 . . .	No. 426	·99956	13°
Elliott, 312 . . .	No. 427	·99911	13°·2
Elliott, 313 . . .	No. 428	·99903	13°
Elliott, 314 . . .	No. 429	·99912	13°·1
Elliott, 315 . . .	No. 430	9·9901	11°·7
Elliott, 316 . . .	No. 431	9·9873	11°·6
Elliott, 317 . . .	No. 432	9·9914	12°
Elliott, 318 . . .	No. 433	100 (1 – ·00014)	14°·1
Elliott, 319 . . .	No. 434	100 (1 – ·00027)	14°
Elliott, 320 . . .	No. 435	100 (1 – ·00023)	13°·9
Nalder, 4651 . . .	No. 436	·99899	13°·8
Nalder, 4653 . . .	No. 437	9·9846	12°

Ohms—continued.

No. of Coil		Resistance of Coil in Ohms	Temperature
Nalder, 4654 . .	No. 438	9·9833	12°·1
Nalder, 4655 . .	No. 439	100 (1 − ·00068)	14°·3
King Mendham . .	No. 440	1·00078	15°·2
Nalder, 4934 . . .	No. 441	·99926	14°·1
Paul, 36 . . .	No. 442	9·9969	13°·7
Wigston, 449 . . .	No. 443	9·9988	14°·3
Wigston, 440 . . .	No. 444	·99888	17°·3
Wigston, 450 . . .	No. 445	100 (1 − ·00030)	17°·3
Wigston, 453 . . .	No. 446	1000 (1 − ·00067)	17°·3
Nalder,[1] 4561 . . .	No. 409	1000 (1 + ·00039)	15°·2

The resistance coils referred to in the last report as defective in insulation have been refilled, and up to the present their insulation has proved satisfactory.

The publication of a paper handed in by Dr. Muirhead, giving further results of tests made by Mr. E. O. Walker on the coils made by Dr. Matthiessen twenty-five years ago, and since exposed to an Indian climate, is deferred until the Cambridge coil, against which they were tested, can be re-examined by the Secretary.

The set of standards ordered from Germany has only just arrived. In the course of the next year a careful comparison will be made between their values and those of the standards of the Association.

During the year the Committee have had under discussion a paper on magnetic units prepared by Dr. Lodge and printed as an appendix to this report, together with a communication received from Dr. Everett.

Taking into account the fact that the question of magnetic units is still under discussion by various bodies, the Committee wish to come to no hasty decisions, but they recommend for tentative adoption the following terminology :—

1. That, as a unit for magnetic field, a hundred million 'c.g.s. lines' be called a *weber*.

Note.—A weber added per second at a steady rate to the field girdled by a wire circuit induces one volt in every turn of that circuit.

Hence the webers 'cut' by a closed wire circuit of n turns are equal to the quantity of electricity in coulombs thereby impelled round that circuit multiplied by $\frac{1}{n}$th its resistance in ohms.

2. That the c.g.s. unit of magnetic potential or of magneto-motive force be called a *gauss*.

Note.—An ampère-turn corresponds to $\frac{4\pi}{10}$ (or 1·2566) gauss.

Hence the number of gausses round any closed curve linked on an

[1] Retested (see Report for 1894).

electric circuit is equal to 1·2566 times the number of ampère-turns in this circuit.

3. That the termination *-ance* be used in general for words expressing the properties of a definite body or piece of matter; *e.g.*, resistance, conductance, inductance, permeance, reluctance, &c.; and that the termination *-ivity* or *-ility* or the like be used for words expressing the specific properties of a material; *e.g.*, conductivity, resistivity, inductivity, refractivity, permeability, &c.

The Committee recommend that they be reappointed; that Professor G. Carey Foster be Chairman and Mr. R. T. Glazebrook Secretary.

APPENDIX.

Magnetic Units.

To the British Association Committee on Electrical Standards.

Believing that the Committee is impressed with the convenience of affixing names to some of the more important units connected with the magnetic circuit, I beg to suggest the following considerations and recommendations, which I will write out as briefly as possible. The statements are intended to be precise in their terms; but in several cases alternative forms of definition are given.

(1) That the unit coefficient of self-induction, though frequently useful, is by no means one of the most fundamental units, but should be defined in a suitably subordinate manner, with reference to other and more important quantities.

(2) That it would be a mistake so to define it as to discourage the employment of the same term for as many other quantities of the same 'dimensions' as possible; especially for the unit coefficient of mutual induction, and for unit 'permeance.'

(3) That the essentially different quantities commonly called H and B should be carefully kept distinct, although their measures in air have been conventionally so arranged as to be numerically equal.

(*Summary of known facts and definitions.*)—H being the intensity of magnetic force at a point, or the slope of magnetic potential (ω),

$$\omega_a - \omega_b = \int_a^b H ds, \text{ along any length } ab;$$

and in a closed magnetic circuit the circuitation of H is equal to 4π times the total electric current through the area bounded by the magnetic circuit; or,

$$\text{cycle} \int H ds = \text{circuitation of H} = \iint 4\pi c dS = 4\pi C,$$

or, at any point of space,

$$\text{curl H} = V \nabla H = 4\pi c;$$

where c is current density.

If the electric circuit consists of n turns of wire threading the magnetic circuit, and each conveying the current C_1, then $C = nC_1$.

First quantity to be named.

(4) The first thing requiring a name is this quantity *magnetic potential*, sometimes called *magneto-motive force*; a quantity spoken of and measured, not inconveniently but with insufficient generality, by electrical engineers as ampère-turns. It has been proposed (by Mr. Heaviside, for instance) that it be called *gaussage*, and that its c.g.s. unit be one *gauss*.

(5) The circuital gaussage round a closed curve is 4π times the total electric current through the area bounded by that curve.

In the case of a magnetic circuit wound with wire the gaussage is $1\frac{1}{4}$ times ($\frac{4\pi}{10}$ or 1·2566) the ampère-turns threading that circuit.

Note.—It may be best to retain the word 'gaussage' for the whole of a closed circuit only, and to speak of the difference of magnetic potential between two points as the fall of gausses or the 'gauss-fall' from a to b.

(6) The gaussage, or gauss-fall, in any portion $a\,b$ of a magnetic circuit, is measured by the change in the potential energy of a unit pole as it moves from a to b by any path which involves neither the cutting of magnetic layers nor the encircling of currents (a long channel being imagined for its motion through solid material if necessary). Or, more practically, it is measured by the induction through a long narrow tube whose ends are at a and b respectively, divided by the permeance of that tube. (*Cf.* Chattock on a magnetic potentiometer, *Phil. Mag.*, July 1887.)

In practice, however, gaussage is frequently calculable from the ampère-turns to which it is due.

(7) Intensity of magnetic force, or H, will be naturally expressed as gauss-fall per centimetre, or the *gauss-gradient*. For instance, the earth's horizontal intensity at some place is ·18 gauss per linear centimetre, or 5·4 gausses per foot.

Note.—H should not (strictly speaking) be expressed as so many lines per square centimetre; that mode of expression should be reserved for induction-density B. H is the cause, and should be thought of as the slope of magnetic potential, B is the effect. In a medium of so-called unit permeability the two quantities are numerically equal, but they should not be confounded; any more than the slope of electric potential, or electric-intensity (e), should be thought of as identical with current-density, even in a medium of unit conductivity.

(8) The gauss-gradient inside a long or closed magnetic solenoid of length l, wound uniformly with n turns of wire each conveying the current C_1, is $4\,\pi n C_1/l = 4\pi n_1 C_1$; where n_1 is the total number of turns of wire (in all the layers) to the linear centimetre.

This is the measure of H in the interior of such a solenoid, quite irrespective of the material with which it may happen to be filled.

(8*a*) That the rotation of the plane of polarisation caused by any transparent body is equal to the number of gausses between the points where the ray enters and leaves the body, multiplied by the appropriate specific constant of its material (sometimes called Verdet's constant); in other words, that Verdet's constant may be expressed in degrees or radians per gauss.

Second quantity to be named.

(9) The second quantity requiring a name is the *total induction* in a magnetic circuit, also called 'total flux,' 'total lines,' 'electro-magnetic momentum,' and 'electrotonic state.' It is the quantity whose time-rate

of variation gives the voltage induced in an electric circuit surrounding it once. It is proposed that its practical unit be called a 'weber,' and be defined as equal to 10^8 c.g.s. lines (or unit tubes) of induction.

(Denote the quantity for the present by N, and its density by B.)

Summary of known facts.—e being the intensity of electric force, or the slope of electric potential, or the volt-gradient at a point; the circuitation of e=the induced EMF in a closed circuit=the rate of change of induction through it;

or,
$$\text{cycle} \int e ds = E = -\dot{N} = -\iint \dot{B} dS;$$

or, at any point of space,
$$\dot{B} = -\text{curl } e = -V \nabla e.$$

Through a simple closed electric circuit of constant resistance,
$$N = -\int E dt = \int RC dt = RQ.$$

(10) The total induction through any area may be practically measured by suddenly surrounding it with a closed wire circuit of n turns connecting the terminals of a ballistic galvanometer, and measuring the quantity of electricity thereby impelled through the galvanometer. The induction is equal to the quantity so impelled, multiplied by $\frac{1}{n}$th the resistance of the circuit. If the quantity is one coulomb, and the resistance one ohm, the induction is $1/n$th of a weber.

Or, otherwise, if the induction through any boundary changes at the rate of one weber per second, the EMF excited in that boundary is 1 volt.

In the case of a spiral wire circuit through which induction is varying at the rate of a weber per second, one volt is excited *in each turn* of the wire.

(11) *Another* mode of measuring the total induction through an area is to surround that area with a movable electric circuit of n turns of wire conveying a known current, and to measure the potential (or mechanical) energy of the circuit under those conditions. The induction is equal to the potential energy of the circuit divided by n times the current circulating in each turn of wire.

Or, if the induction through a simple circuit carrying one ampère is one weber, the potential energy of the circuit is one joule.

Derived quantities.

(12) Induction-density, or B, may be expressed as so many webers per unit area; say per square centimetre or per square inch, or whatever is preferred for practical purposes.

For instance, the earth's horizontal induction-density at some place is ·18 c.g.s. unit, $= \cdot 18 \times 10^{-8}$ weber per square centimetre, =18 microwebers per square metre.

(13) The inductivity (μ), or absolute permeability of a medium at any point under specified circumstances, is the ratio of B to H at that point, and under those circumstances. In many substances this ratio is far from constant. [It may be expressed in terms of henrys or other units of permeance per unit length (see below), instead of in c.g.s. units, if convenient. For example, the inductivity of air is $\frac{1}{100}$th of a microhenry per centimetre

or one millihenry per kilometre.] More explicitly it is measured by the webers per unit area divided by the gauss-fall per unit length; in other words, by the ratio of the weber-density to the gauss-gradient.

(14) The relative inductivity of a substance as compared with that of empty space (μ/μ_0) may be called simply its 'permeability' as at present, and is a mere number.

(Its electrical analogue is specific inductive capacity (κ/κ_0), as contrasted with absolute electric inductivity (κ); which latter could be defined in practical units as the ratio of the coulombs displaced per unit area to the volt-gradient.)

Third quantity to be named.

The third quantity for whose unit a name is required is some form of ratio between the two fundamental quantities whose units are here named after Weber and Gauss respectively. It has been practically decided in America that this unit shall be named after Prof. Henry, of Washington, and that it shall equal 10^9 c.g.s. units, being equivalent to the earth-quadrant or secohm; but the precise mode of definition has not yet been finally agreed upon.

There are two quantities of the same physical dimensions to which the name is applicable, viz., the coefficient of self or mutual induction of a coil or coils of wire, and the permeance or inverse reluctance of a magnetic circuit.

The most logical order is to define permeance first, as the ratio of the webers of induction to the exciting gaussage, and then to say that the inductance of a coil of n turns of wire is n^2 or $4\pi n^2$ or $\cdot 4\pi n^2$ times the permeance of the magnetic circuit which it embraces, according to the units of gaussage and current which have been decided on.

If the units of gaussage and current are both the c.g.s. units, then $4\pi n^2$ is the numerical factor connecting inductance with permeance.

If the c.g.s. unit of gaussage is adopted along with the ampère-current, then $\cdot 4\pi n^2$ is the factor.

But if the circulation of H due to *one ampère-turn* is adopted as the practical unit of gaussage, then n^2 is the factor; and the permeance of a cylinder, instead of being simply $\frac{\mu A}{l}$, is $\frac{4\pi\mu A}{10l}$.

The apparent simplicity of this last system has much to recommend it for commercial use, though it will complicate the specification not only of permeance but also of magnetic fields and potentials; but *some* inconvenience due to the unfortunate definition of the unit pole, and the only less unfortunate definition of the practical unit of current, cannot be avoided; and our aim must be to place the inconvenience where least likely to be felt in every-day work.

First system.

We will begin with the more logical system, and with general statements which apply to both.

(15) In a complete magnetic circuit the ratio of the total induction to the corresponding gaussage under specified conditions is called the 'permeance' of that circuit under those conditions. It is not in general constant.

Or, the permeance of any solenoidal portion of a magnetic circuit, if free from intrinsic magneto-motive force or magnetic boundary layers, is the webers through it divided by the gausses between its ends.

(16) The practical unit of permeance is that of a circuit in which a weber is excited by a gauss. Its reciprocal is the unit of reluctance. The practical unit so defined is 10^8 c.g.s. units.

Examples.—The permeance of a cubic metre of air to parallel induction from one face to the opposite is 1 microweber per gauss.

Under circumstances such that the permeability of iron is 400 times that of air, the permeance of an iron ring of one decimetre cross section and one metre in mean diameter is $\frac{400\pi r^2}{2\pi R} = 20r = 100$ c.g.s. = again one microweber per gauss.

It is, perhaps, a question whether this amount of permeance could be called 'a microhenry' without confusion.

Explanation.—The inductance (or self-induction-coefficient) of an electric circuit consisting of n turns of wire, so far as it is constant, is defined to be equal to n times the induction produced through it by a current of one ampère in each turn. But the gaussage due to n ampère-turns is $\frac{4\pi n}{10}$ or $\cdot 4\pi n$; hence the inductance of a wire coil is $\cdot 4\pi n^2$ times the webers caused by each gauss in the magnetic circuit surrounded by it; *i.e.*, is $\cdot 4\pi n^2$ times the permeance of that circuit considered as constant.

(17) A coil of wire threading n times a complete magnetic circuit of unit permeance under any given circumstances is said to have $\cdot 4\pi n^2$ units of inductance under those circumstances; and in general the inductance of a coil of n turns is $\cdot 4\pi n^2$ times the permeance (as above defined) of the magnetic solenoid enclosed by it. (The permeance may here be considered variable.)

[With the ampère-turn as unit gaussage the $\cdot 4\pi$ is prefixed similarly to both inductance and permeance, so that only the factor n^2 is needed to convert one into the other. See below.]

(18) The c.g.s. unit of inductance is equal to n times the induction excited through a coil per c.g.s. unit of current in every turn of wire; whereas the practical unit of inductance is n times the webers excited per ampère; hence the practical unit of inductance is 10^9 times the c.g.s. unit.

The practical unit is called a 'henry.' (It has also been called secohm and quadrant.)

Example.—If the above iron ring were wound closely with 1000 turns of wire, the coil would have a coefficient of self-induction equal to $\frac{4\pi}{10}$ or $1\frac{1}{4}$ henrys whenever the permeability of the iron was 400.

A coil of 20,000 turns of wire, wound closely on the same core, would have an inductance of $1\frac{1}{4}$ henrys if it contained air or other non-magnetic substance.

Alternative mode of definition of inductance on first system.

In view of one of the above practical methods of measuring induction experimentally, the inductance of coils of wire, both self and mutual, may be defined more directly thus :—

(19) When of two simple circuits one conveys a current, the other in general has induction caused through it; and the ratio of the induction

through either to the inducing current in the other is called the mutual inductance of the circuits.

(20) Of two coils, with n and n' turns respectively, the total mutual inductance is to be reckoned for every turn of wire on each coil, and is therefore nn' times the inductance of the mean turn of one coil on the mean turn of the other.

(21) The mutual inductance of two coils is $4\pi nn'$ times the permeance of the largest magnetic solenoid which threads both. For if every turn of one conveys a current C, while every turn of the other surrounds an induction N′ in consequence, the permeance of the magnetic solenoid threading the second coil is $P=N'/4\pi n C$; but the total effective mutual induction, MC, through all the turns is $n'N'$; hence $M=4\pi nn'P$.

(22) When two coils each conveying one ampère are constantly connected by one henry of mutual inductance, the kinetic energy of the field due to their mutual action is one joule.

(23) If the *self*-induction coefficient of a coil is being considered, its total inductance may be taken as n^2 times the inductance of the mean turn; that is n times the total induction through it divided by the inducing current. Or the weber-turns per ampère give the self-inductance in henrys.

(23*a*) The expression weber-turns, to signify the product of the total field into the number of spires surrounding it, though at first sight not in precise correspondence with the phrase ampère-turns where the current circulates in the spiral instead of forming its core, is really accordant with it, because a spiral and its core are geometrically interchangeable.

(24) The practical unit of inductance, whether self or mutual, is called a henry ; and a coil of n turns has a henry of inductance, on itself or on another of n' turns, when an ampère in one maintains $1/n'$ weber of induction (through itself or) through the other.

(25) When the induction through a coil varies for any reason at the rate of one weber per second, the E.M.F generated in each turn is one volt.

(26) When the inductance of a soil is one henry, on itself or on another, a small variation of current in it at the rate of one ampère per second induces an EMF of one volt in itself or in the other.

(27) When the inductance of a coil conveying one ampère varies at the rate of a henry per second, the induced E.M.F is one volt.

(28) When the self-inductance of a coil is constantly, or on the average, one henry, while an ampère current is generated in it, the kinetic energy of the field due to that ampère is half a joule.

Second system.

(29) If instead of taking a gauss as equal to a c.g.s. unit of magnetic potential, we take the circulation of H caused by one ampère-turn as the practical unit of magneto-motive force, we shall have 1 ampère-turn $=\frac{10}{4\pi}$ c.g.s. units of gaussage.

(30) The practical unit of permeance will then be that in which a weber of total induction is excited by each ampère-turn ; in other words, it will be $4\pi\times10^7$ c.g.s. units of permeance.

(31) And the practical unit of inductance will be that of a coil in which an ampère in every turn excites $\frac{1}{n}$th of a weber through every

turn; that is to say, the inductance of a coil will be n^2 times the permeance of the magnetic circuit surrounded by it.

(32) The difference between inductance and permeance is only one of reckoning. Permeance is webers per ampère-turn. Inductance is weber-turns per ampère.

SUMMARY OF THE ADVANTAGES OF THIS MODE OF DEFINING UNIT INDUCTANCE.

The special feature of this mode of defining the 'henry' is that it makes inductance depend on the simple ratio N/C, or weber-turns per ampère, instead of on something more complicated.

It might possibly be defined as the ratio dN/dC, that is, as proportional to the tangent of the slope of the B : H curve; and such a definition would emphasise its variability; but certain practical advantages would be lacking, because it would be detached from any connexion with the *permeance* of the circuit. The N/C ratio on the other hand instantly connects itself with permeance, and represents the slope of the secant drawn from the origin to any point of the B : H curve. It exhibits the variability sufficiently; making the inductance reach a maximum at the shoulder of the curve, and then slowly decrease as saturation sets in.

It is sometimes said—but the mode of expression is, to say the least, very inconvenient—that there are three different principles on which to define L, all leading to a different result: viz., numbering them inversely, but giving them in their usual order:—

(3) Energy . . . $W=\frac{1}{2}LC^2$
(2) E.M.F . . . $E=L\,dC/dt$
(1) Total induction $N=LC$

But the real facts to be expressed are not here exhibited. The real facts are

(1) $N=LC$
(2) $E=dN/dt$
(3) $dW=C\,dN$

The essential thing to name is therefore N; and if 10^8 c.g.s. lines or unit tubes be called a 'weber,' or a 'weber-turn,' then a volt is a weber or a weber-turn per second, and a joule is a weber-ampère-turn. Nothing can be handier than that; and a henry can be defined as a weber-turn per ampère.

Instead of saying as above that there are three ways of defining L, the simplest thing is to say that two of the three equations as first given above are incorrect, except for the special and in practice comparatively rare case when L is constant. Written out correctly they stand as follows:—

(1) $N=LC$

(2) $$E=L\frac{dC}{dt}+C\frac{dL}{dt}$$

(3) $$W=\frac{1}{2}LC^2+\frac{1}{2}\int_0^c C^2 dL$$

It is then obvious that (2) and (3) are too complicated to base a definition upon, and that the first alone gives a feasible system.

The fact that L is decidedly not in general constant deprives the henry of any such importance as the ohm possesses; moreover, it refers explicitly to rather a special thing, viz., a coil of wire, and that under specified conditions, if it contain iron; hence it would be rather absurd to name this alone of all magnetic units. In the above communication, in addition to a certain mode of defining the henry, it is urged that unit total induction be named too; for this is the quantity which is of real engineering importance—this is the quantity to attain which field-magnets are built, and in the midst of which armatures are spun.

It is also urged that it would be convenient if unit magnetic potential could likewise be named, since electrical engineers have shown that they have need of some such unit for the exciting cause of induction, by their practical employment of the phrase 'ampère-turns.' The introduction of a gauss unit, in some form not too obviously limited to the case of a wire-wound coil, would assist teaching and would clarify magnetic ideas.

The present writer does not presume to decide between the two alternative systems of defining 'the gauss' as given above: viz., the c.g.s. unit on the one hand, and the ampère-turn on the other.

OLIVER J. LODGE.

Liverpool: *December* 9, 1894.

Postscript.—Another subject for discussion is whether L had better not be defined as dN/dC; with permeability as $\mu=dB/dH$ to correspond. This would make the three equations of page 203 stand thus:—

$$(1)\ N=\int L dC$$

$$(2)\ E=L\dot{C}$$

$$(3)\ \dot{W}=C\dot{N}$$

A letter just received from Mr. Heaviside indicates that he would probably favour this course, and there is evidently much to be said for it. I need hardly add that he contemns my temporising method of dealing with the 4π nuisance.

It need hardly be said that in the last resort it rests with practical men to employ or decline any suggested system of units. Those who daily deal with the quantities under consideration are the best judges of the utility or otherwise of a suggested unit, provided always that they take the trouble to give it a fair trial, and see how it works in practice. It may be hoped that the above or similar suggestions will meet with criticism at the hands of such men, and in order to make a beginning of criticism I asked the Departmental Lecturer on Electrotechnics at University College, Liverpool (Mr. F. G. Baily), to consider them with special reference to

(1) The large size of the weber and henry units;
(2) the handiest definition of the gauss; and
(3) the least troublesome mode of bringing in the 4π.

His reply, which is annexed, covers these points, and also incidentally refers to the quantity called I or intensity of magnetisation.

Now, as must often have been pointed out, the equation $B=H+4\pi I$ is a barbarous one, involving as it does quantities of different dimensions in one equation. Its true meaning is of course $B=\mu_0 H+(\mu-\mu_0)H$; which, although algebraically only a roundabout method of writing $B=\mu H$, is yet convenient, as exhibiting separately the part of the induction due to the ether and the part due to a material medium.

The customary convention of further denoting $(\mu - \mu_0)/\mu_0$ by the symbol $4\pi\kappa$, and then christening κH as the magnetisation I, is likewise convenient. With this definition κ is a pure number, and I is a gauss-gradient or field-intensity. Another, but on the whole less satisfactory, definition, viz., the omission of μ_0 from the denominator, would make κ of the same dimension as μ, and I an induction-density.

The pull between two parallel magnetised surfaces of area A is $\frac{1}{2}$ABH $\div 4\pi$, that is to say, NH$/8\pi$, and is therefore measured in webers multiplied by the gauss-gradient, or in joules per centimetre. But to maintain an induction density B in air requires a gauss-gradient B/μ_0, hence we might write the pull across an air-gap as $N^2 \div 8\pi\mu_0 A$. If the induction-density across an air-gap is expressed in microwebers per square centimetre the tension there comes out in units of which 2,500 would make an atmosphere; or, roughly, in pounds per square foot.

As for the strength of a magnetic pole—a quantity which, though fundamental in one sense, is seldom really dealt with—it will naturally be expressed in ergs per gauss, or in joules per gauss if it is very strong.

Mr. Baily's chief practical suggestions are first that a special unit of permeance, other than the henry, is desirable; and next that the $4\pi/10$ had best be thrown on to the μ, so as to keep the gauss equal to one ampère-turn. The fact that the inductivity of air will then cease to appear in its artificial garb of unity may even be regarded as a positive advantage, because its existence will then be less likely to be ignored. But I much fear that the ampère-turn as unit of gaussage, so near the c.g.s. unit in size and yet not equal to it, will be awkward and may lead to mistakes.

O. J. L.

University College, Liverpool: *January* 15, 1895.

DEAR PROFESSOR LODGE,—In reference to the sizes of the magnetic units proposed by you, I find that the weber 10^8 c.g.s. would only be used in fractions. The largest dynamo that I know of has a magnetic flux, or, as you propose to call it, an induction, of ·5 weber. From this the value will go down to about ·01 in small motors. These figures are, however, by no means inconvenient.

Transformers will be rather smaller. In these the weber-turn is a convenient size and an interesting quantity, as it is given by $\frac{1}{4}$ *of the mean volts per cycle*, or, more accurately expressed, *mean volts per unit frequency* $\div$ 4. Its numerical value will lie between, say, $\frac{1}{4}$ and 50, according to the volts and the frequency; but it gives no indication of the size of the transformer.

The henry, 10^9 c.g.s., is also large. The inductance of choking coils would in general be fractions of a henry. The inductance of the winding of a transformer has no very important meaning, but it has a convenient size. Measuring it as *mean volts per unit frequency* $\div$ *four times the open circuit current in ampères*, the inductance of the primary coil on a 2 HP closed magnetic circuit 1,000-volt transformer would be about 40 henrys.

The inductance of pairs of cables would run from 100 to 1,000 microhenrys per kilometre, but the value would vary with the arrangement.

The induction per unit area is good; having a value in practical work from 1,000 to 20,000 c.g.s. units, it is given by 10 to 200 microwebers per sq. cm.

Gaussage would be about 50 in small transformers, up to 40,000 in large dynamos. The latter could be conveniently reckoned in kilogausses. To make the gauss = 1 ampère-turn appears to have great advantages in practice, and connects it directly with its usual source.

The idea of permeance is very useful, and the identification of its dimensions with those of inductance is neat. But I think it is liable to cause confusion, for the permeance of the core of a coil will be a different number of henrys from the inductance of its wire. Moreover, the argument as to identical dimensions might equally be applied to the case of ampères and gausses. I would therefore have a new unit strictly connected with the henry, so that inductance$=n^2\times$permeance in a coil of n turns.

As to the units of permeance: with the above meanings of gauss and weber the permeance of a circuit would be $4\pi\mu A/10l$, as you point out, instead of $\mu A/l$. But I wish to suggest a change in the method of reckoning, namely, still to retain the value of the permeance as $\frac{\text{webers}}{\text{gausses}}$, and permeability as $\frac{\text{webers per sq. cm.}}{\text{gausses per cm.}}$, therein giving up the convention of unit permeability of space, and giving it the value $1{\cdot}2566\times10^{-8}$ unit of permeance for a unit cube. In this way both the troublesome 10^{-8} and $4\pi/10$ are dealt with in an easily intelligible way. To avoid the high power of 10 it may be measured in micro-units of permeance, so that permeability of space and air$=\cdot012566$ micro-unit of permeance for a unit cube, and permeability of soft iron$=$up to 25 micro-units for a unit cube. Thus we have permeance$=A\mu/l$, where μ is to be obtained from tables of its value, which can easily be altered to this method. Inductance then becomes $\frac{\text{weber-turns}}{\text{ampères}}$, or $n^2\frac{\text{webers}}{\text{gausses}}=n^2$ permeance.

[Of course your phrase 'weber-turns per ampère' means the same as the above webers ÷ ampères, and does not necessarily mean the weber-turns caused by one ampère.]

It may be objected that the c.g.s. units of strength of field, unit magnetic pole and intensity of magnetisation do not bear any simple relation to these practical units. This is chiefly important in the use of the magneto-metric measurement of iron, and in the measurement of the mechanical form of attraction between two magnetic surfaces in contact. But the expressions are not in reality much complicated; *e.g.*, present c.g.s. unit of intensity of magnetisation is given by $4\pi I=(\mu-\mu_s)\,H$, where $\mu_s=$permeability of space$=1$, and $H=$c.g.s. unit of magnetic force. This becomes $4\pi I=(\mu'-\mu'_s)\,H'\,10^8$, where H' is the gauss-gradient in the magnetic substance, and $\mu'_s=\cdot012566$ micro-unit of permeance for a cubic centimetre.

As the single magnetic pole is unchanged, the force on it will be = strength of pole × gauss gradient × 1·2566; but as this is not a calculation of frequent occurrence, except in magnetic surveys, the complication will not be serious. Other magnetic relationships are almost entirely of academic interest only, and would be carried out in c.g.s. units. Also the transition would present no difficulties to people with a little scientific knowledge.

I am of opinion also that as the legal volt has no direct connection with induction and velocity of motion, it is not necessary to define the practical units as they are defined absolutely. That is, ohm and ampère are the starting points, volt is obtained from them, weber from volt, gauss from ampère, permeance unit from weber and gauss, henry from weber and ampère or from permeance, and so on. This is much more easily explained to practical and unscientific men than the absolute derivations are, and it is the order in which they learn them.

Yours very truly,
FRANCIS G. BAILY.

REMARKS ON THE ABOVE (especially on pages 203 and 204).

According to the proposal of the Chicago Chamber of Delegates, the quantity which we call 'inductance,' and which is to be expressed in 'henrys,' is defined by the equation

$$E = L\frac{dC}{dt}, \text{ for self-induction,}$$

or

$$E = M\frac{dC}{dt}, \text{ for mutual induction,}$$

both being comprehended in one definition, the inductance L or M being calculated by dividing E in volts by $\frac{dC}{dt}$ in ampères per second. This implies that L or M is not to be defined as $\frac{N}{C}$, but as $\frac{dN}{dC}$.

I think names are desirable both for $\frac{N}{C}$ and for $\frac{dN}{dC}$. I would suggest that the former be called 'the total inductance,' and the latter 'the differential inductance.' The distinction would be somewhat analogous to the distinction between the 'mean specific heat from 0° to t°' and the 'true specific heat at t°.' Both total and differential inductance should be expressed in 'henrys,' for they are quantities of the same kind, and when there is no iron, &c., in the field they are equal.

I think that the above mode of definition, involving as it does no magnitude except current and time, is more readily comprehended than Dr. Lodge's proposed definition, in which the magnitudes involved are current, flux of induction, and the number of convolutions of the coil through which the flux passes. In the definition proposed by the Chicago delegates the consideration of the number of convolutions does not enter.

For a circuit or two circuits not having iron, &c., in the field we may define inductance (in henrys) as the E M.F. (in volts) due to variation of current at unit rate (one ampère per second). When the field is modified by the presence of magnetic material the above will be the definition of 'differential inductance.'

The 'total inductance' for any specified strength of current will be the mean value of differential inductance for equal increments of current from zero up to the specified strength.

I would suggest similar nomenclature in the case of permeability: $\frac{dB}{dH}$ should be called differential permeability, and $\frac{B}{H}$ total permeability.

In some respects 'mean' or 'average' would be a more correct designation than 'total'; but these words would be liable to be misunderstood as referring to an average taken over the different parts of the body or circuit. 'Total' is to be understood as standing for 'calculated on totals.'

As regards the magnitude of the unit of inductance. While I agree with Mr. Heaviside and Dr. Lodge that the unit pole ought to have been so defined that the mutual force between two poles is equal to their product divided by the surface of a sphere whose radius is their distance, a definition which would have made the line-integral of H due to a current C equal to C itself instead of to $4\pi C$, I deprecate a mixing up of the two systems. So long as we employ our present unit of intensity of magnetic field, which results from our present definition of the unit pole, we cannot consistently reckon the line integral as equal to the ampère-turns. It must be reckoned as 4π times the ampère-turns, and the flux N must be reckoned as $4\pi\mu$ times the ampère-turns. The practical inconvenience of retaining the factor 4π cannot be considerable, for it is as easy to tabulate the values of $4\pi\mu$ as the values of μ.

Next as regards 'permeance.' I do not think it can conveniently be reckoned in henrys. I would rather reckon it in 'webers per ampère-turn,' which would be written 'web. per amptu'; and there can be no possible doubt as to the meaning intended when once we have fixed the magnitude of the 'weber.' There seems to be no difference of opinion as to what this magnitude should be. It is fixed by the relation $E = \frac{dN}{dt}$, E being in volts, N in webers, and t in seconds. This is in accordance with Dr. Lodge's proposal; but Dr. Lodge has not explicitly recommended any name for the physical quantity which is measured in webers. Shall we call it 'weberage'? It greatly needs a name; for 'induction' may mean B instead of the surface integral of B, besides having many other meanings.

When permeance varies according to the strength of current, I would distinguish between 'total permeance' $\frac{N}{nC}$ and 'differential permeance' $\frac{1}{n}\frac{dN}{dC}$.

As regards 'gaussage' and 'gauss fal I think the names will be convenient in the senses proposed by Dr. Lodge, but I cannot agree with his selection of a unit of measurement. The present definition of the unit pole (on which the present unit current is based) requires us to equate the line-integral in question to $4\pi nC$.

To be consistent we must reckon gaussage as equal to 4π times the number of amptus. Dr. Lodge's proposal is to reckon C, not in ampères but in c.g.s. units, thus introducing, as it appears to me, an awkward breach of continuity.

J. D. EVERETT.

Professor Carey Foster has written objecting to the term 'gauss-gradient,' instead of 'magnetic gradient'; he prefers the latter, just as he would prefer 'temperature-gradient' to 'degree-gradient.'

Dr. Johnstone Stoney has also written, urging strongly that not the c.g.s. unit of magnetic potential, but one-tenth of this quantity, should receive a name, in order to make it harmonise with the ampère series; and further recommending that the names 'weber' and 'gauss,' as above suggested, should be interchanged.

Comparison and Reduction of Magnetic Observations.—Report of the Committee, consisting of Professor W. G. ADAMS (*Chairman*), Mr. C. CHREE (*Secretary*), Lord KELVIN, Professor G. H. DARWIN, Professor G. CHRYSTAL, Professor A. SCHUSTER, Captain E. W. CREAK, The ASTRONOMER ROYAL, Mr. WILLIAM ELLIS, *and* Professor A. W. RÜCKER. (*Drawn up by the Secretary.*)

[PLATES V. and VI. *Thirteen Curves illustrating Results in* §§ 7–8 *and* §§ 11–12.]

Analysis of the Results from the Kew Declination and Horizontal Force Magnetographs during the selected 'Quiet' Days of the Five Years 1890–94. *By* C. CHREE, *Sc.D.*

CONTENTS.

Introduction.

§ 1. THE hourly measurement of the Kew magnetic curves on five 'quiet' days a month, selected annually by the Astronomer Royal, has been in operation since the beginning of 1890. Tables of the mean hourly values for each month of the declination, inclination, horizontal and vertical forces, based exclusively on these quiet days, have been published annually in the 'Report' of the Kew Committee to the Royal Society. Tables have also been given of the mean diurnal variations of the several elements for the six winter months, the six summer months, and the whole year.

With the consent of the Kew Committee I now propose to give a general *résumé* of the results deducible from the declination and horizontal force records on the selected quiet days of the five years 1890–94.

For some reasons it would have been desirable to allow a larger number of years' records to accumulate before entering on a general discussion; to have included, for instance, the complete cycle of ten or eleven years believed to occur in magnetic phenomena would have possessed obvious advantages. On the other hand twenty-five quiet days for each month of the year seem a sufficient number for a comparison of the different months. Further, the frequent occurrence of certain phenomena, depending apparently on the limitation of the inquiry to 'quiet' days, which cause an appreciable amount of indeterminateness in the results, has led me to think an early survey of the situation desirable.

§ 2. The first thing to consider is the distribution of the selected 'quiet' days. The aim of the Astronomer Royal, he informs me, has been to ensure, first, that the five days selected each month are good specimens of 'quiet' days; and, secondly, that their mean comes near the middle of the month. That the second object has been very satisfactorily accomplished, so far as a five years' survey is concerned, will be seen from the following table. The figures it contains are the intervals, in days, from the beginning of the month to noon of its mean 'quiet' day, the 300 'quiet' days being grouped under the months to which they belong.

TABLE I.

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
17	13·3	15·7	15·6	16·0	15·3	15·3	15·6	13·3	16·7	13·7	15·5

In one of the 300 'quiet' days the Kew record was defective and has been omitted. Its omission reduces the entry in the table under August from 15·6 to 15·0.

The departures from the theoretically exact figures, 15·5 for months of thirty-one days and 15 for months of thirty days, are so small, considering the uncertainties arising from other sources, that I have decided to neglect them in getting out annual variations. Equal weight has also been allowed to each month.

§ 3. In 1890 the diurnal variation at Kew was got out from measurements at the hours[1] 1 to 24, counting from midnight. What has been styled in the Kew 'Report' 'solar diurnal range' meant in that year the departure of the hourly values from the mean for the day taken as

$$\{[1]+[2]+ \quad . \quad . \quad . \quad . \quad +[24]\}/24\,;$$

where by $[n]$ is meant the value answering to the nth hour after the first midnight. In the subsequent four years measurements were taken at the first as well as the second midnight, and the mean for the day was taken as

$$\{[0]+[1]+ \quad . \quad . \quad . \quad . \quad +[23]+[24]\}/25.$$

This second method of fixing the daily mean is of course not mathematically correct, as it attributes double weight to the midnight value; but the departure of the midnight value from the mean for the day—at all events when inequalities are got out only for summer, winter, and the whole year—is too small to cause appreciable error. The error in definition, if error it can be called, was, I think, fortunate for several reasons. For instance it left no additional measurements to be made for the present inquiry other than those at the first midnights of the sixty 'quiet' days of 1890.

Non-cyclic Nature of Results obtained from Quiet Days.

§ 4. During the five years considered, the westerly declination at Kew has been diminishing by about $6'\cdot9$ annually, the horizontal force increasing by about 195×10^{-6} C.G.S. units. Thus on an average there occurred in twenty-four hours a decrease of about $0'\cdot019$ in declination, an increase of about 53×10^{-8} C.G.S. units in H.F. (horizontal force). Now at Kew, declination is measured only to $0'\cdot1$, and H.F. to 1×10^{-5} C.G.S. units. It is thus obvious that if two sets, each of 150 days, and

[1] As in the Kew *Reports*, Greenwich, not local, time is employed. Local time is, however, only 1 min. 15 sec. later than Greenwich time.

twelve sets, each of twenty-five days, had been selected at random, the mean diurnal variation got out from either set of 150 days would in all probability have appeared almost truly cyclic, and the mean diurnal variations got out from the twelve sets of twenty-five days might have been expected, if not truly cyclic, to show about equally many increments and decrements of the element considered in the twenty-four hours. How far the actual result differs from this ideal is shown by the following table.

The 'total increment' means the algebraic sum of excesses of the values of the element considered at the second midnights of the twenty-five quiet days in a month over the values at the first midnights ; in other words, it equals twenty-five times the mean increment during a 'quiet' day in the month specified. The five years supply of course five Januarys, &c., or sixty individual months in all.

TABLE II.

Month	Declination				Horizontal Force			
	Total Increment in 25 'quiet' days	Number of Individual Months			Total Increment in 25 'quiet' days	Number of Individual Months		
	′	+	zero	−		+	zero	−
January . . .	+16·0	5	0	0	$+10^{-5}\times 125$	4	0	1
February . . .	+ 9·5	3	0	2	,, 135	4	1	0
March . . .	+ 6·5	3	0	2	,, 60	4	1	0
April . . .	+ 4·5	3	1	1	,, 40	3	1	1
May	+ 6·5	3	0	2	,, 110	4	1	0
June. . . .	− 6·5	2	0	3	,, 35	3	1	1
July	−11·0	2	0	3	,, 50	3	2	0
August . . .	− 7·5	1	1	3	,, 115	5	0	0
September . .	+ 4·0	3	0	2	,, 85	5	0	0
October . . .	+ 3·5	2	1	2	,, 125	5	0	0
November. . .	+ 6·5	3	1	1	,, 130	5	0	0
December. . .	− 3·0	1	1	3	,, 30	4	0	1
Totals . .	+29′·0 in 300 days	31	5	24	$+10^{-5}\times 1040$ in 300 days	49	7	4

According to Table II. if every day behaved like a 'quiet' day there would be an annual increase of 35′ in westerly declination, instead of the actually existing decrease of 7′, and an increase of 1265×10^{-5} C.G.S. units in H.F., instead of the actually observed 20×10^{-5}.

Taking the figures as they stand, the evidence in favour of a general tendency to a non-cyclic variation in the direction of increasing westerly declination during 'quiet' days is perhaps not conclusive. Of the individual months' records twenty-four show a decrease, and the balance the other way *might* be pure chance. The figures relating to the horizontal force, however, unless ascribable to error, prove conclusively that during the five years in question the force increased at a wholly abnormal rate on 'quiet' days. It is difficult to imagine any cause of error working so uniformly throughout the year. Supposing uncompensated temperature effect to exist, for instance, the phenomenon should tend one way during one season, the opposite during another. The interval between successive 'quiet' days varied arbitrarily, so that the positions of the two midnights of a 'quiet' day on the photographic sheets were constantly being interchanged. It may also be added that the phenomenon is not peculiar to Kew, but may be seen in the published Greenwich and Falmouth results for the same epoch.

§ 5. The phenomena seem not unlikely to be only another phase of phenomena observed many years ago by General Sabine and Dr. Lloyd. The former from a careful study of what he termed 'disturbances' concluded that the aggregates of easterly and westerly declination disturbances at Kew during 1858–62 nearly balanced, 'there being in some years a slight preponderance of westerly, and in other years of easterly deflection;'[1] at the same time he found[2] 'a slight preponderance of easterly values on the average of the four years (1858–61).' As regards the horizontal force he deduced[3] from 5,932 disturbed observations at Kew during 1858–64 that 'the ratio of the value of the disturbances decreasing the (horizontal) force to those which increased it was nearly as 3·23 to 1.' In agreement with this last result Dr. Lloyd found[4] from an examination of the 335 (?) most disturbed days at Dublin during the ten years 1841–50 that 'the mean effect of disturbances is to diminish that (the horizontal) force.'

The significance of these results, when taken along with the tendency suggested by Table II. to a slight abnormal increase of westerly declination on quiet days, and the clear evidence of an abnormal increase of horizontal force on these days, need not be dwelt on. Although the vertical force lies outside our present inquiry, it may not be amiss to mention that evidence of a connection of the kind foreshadowed above is also supplied by it. The results, in fact, from the last five years at Kew show a distinct abnormal *decrease* of vertical force on 'quiet' days, while General Sabine observed a very decided preponderance of disturbances to be associated with *increasing* vertical force.

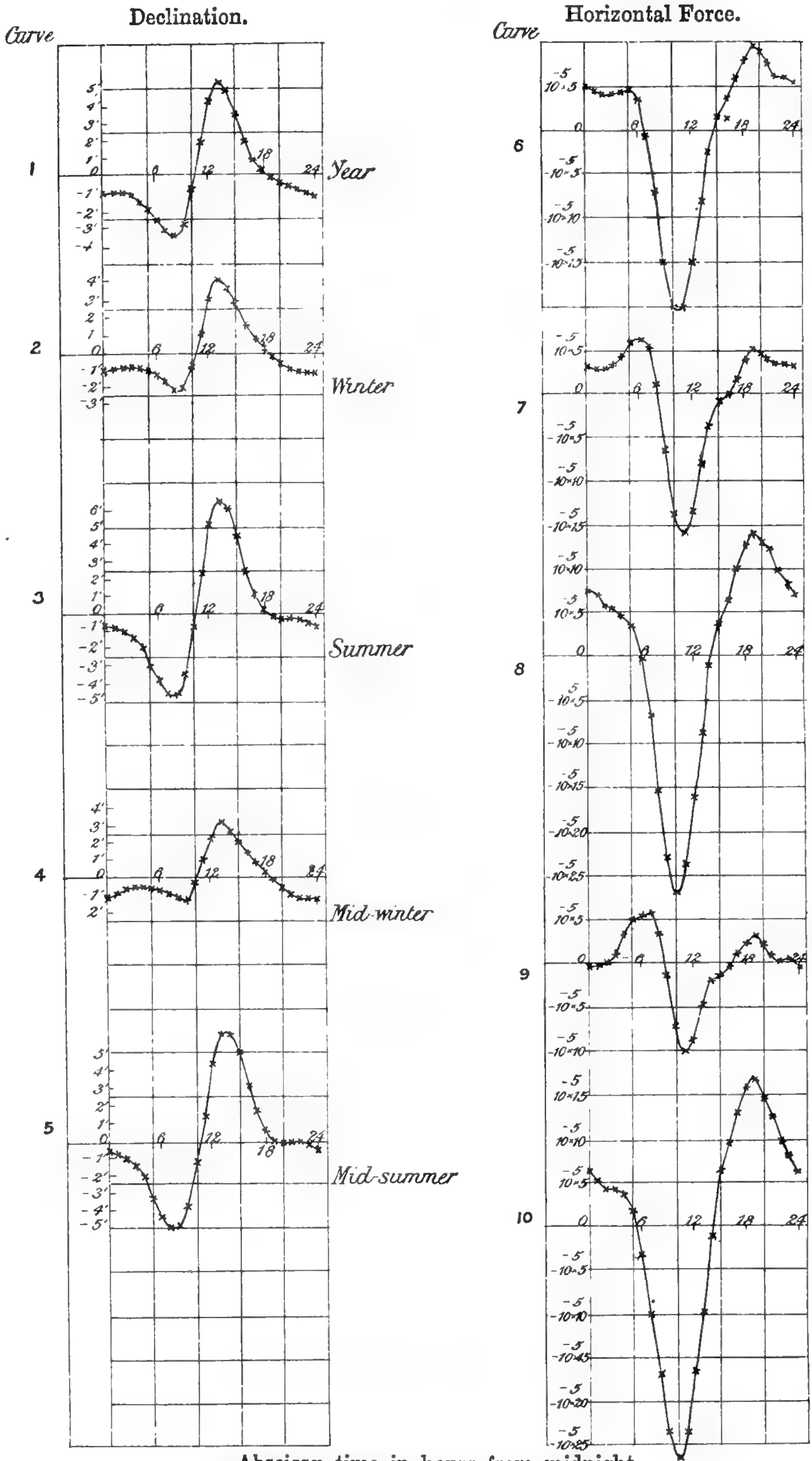
Whether the species of opposition in the phenomena exhibited by the horizontal and vertical forces is to be associated with the fact that at present the former element is increasing the latter decreasing seems an interesting speculation, but it lies outside our present inquiry.

Method of Treating the Non-cyclic Diurnal Element.

§ 6. General Sabine got out tables according to which 'disturbances' at Kew were by no means uniformly distributed over the twenty-four hours; further he found that disturbances associated with easterly deflections had different hours for maxima and minima from disturbances associated with westerly deflections, and a like difference appeared between disturbances associated with increasing and those associated with decreasing horizontal force. If this be so, and if the non-cyclic phenomena observed on 'quiet' days be in any way complementary to the disturbed phenomena, then there is certainly ground for suspecting that the abnormal increase, say, of H.F. observed in the mean 'quiet' day of a certain month is not uniformly distributed over the twenty-four hours. While fully recognising the uncertainty of the hypothesis of uniform distribution of the non-cyclic element, I have unhesitatingly adopted it provisionally. What General

[1] *Phil. Trans.* for 1863, p. 282.
[2] *Proc. Roy. Soc.*, vol. xi. p. 590.
[3] *Phil. Trans.* for 1871, p. 310.
[4] *A Treatise on Magnetism*, p. 211.

DIURNAL INEQUALITY.



Abscissæ time in hours from midnight.

Illustrating the Report on Comparison and Reduction of Magnetic Observations.

Sabine termed 'disturbed' observations included only some 10 per cent. of the entire number; so that, even supposing the years to which his results and the present results applied had been the same, it would hardly have been possible to utilise his results in framing a better hypothesis. Some light might have been thrown on the subject by taking measurements at each hour of every day immediately preceding or succeeding a 'quiet' day, and examining the magnitude of the non-cyclic element for each combination of twenty-four consecutive hours. The fact that this would have entailed some 12,000 additional measurements put it out of court so far as the present inquiry was concerned.

I have thus decided to regard the variation of an element throughout the typical 'quiet' day of a given month as composed of first a non-cyclic part, consisting in a uniform increase or decrease throughout the twenty-four hours, second a truly cyclic part spoken of as the *diurnal inequality*.

Thus suppose an increment 24 I to occur during the twenty-four hours; then the diurnal inequality is what remains of the observed hourly departures from the mean for the day after the correction $(12-t)$I has been applied, t denoting the number of hours elapsed since midnight. This correction raises the values throughout one half of the day and depresses them throughout the other. It of course leaves unchanged the mean value

$$\{\tfrac{1}{2}([0]+[24])+[1]+ \ . \ . \ . \ +[23]\}/24,$$

and after its application

$$[0]=[24].$$

The size of the correction applied to each month's results for declination and horizontal force is obvious from Table II., so that the uncorrected values can easily be reproduced from the corrected ones recorded presently.

Tables of Diurnal Inequality and their Discussion.

§ 7. The following tables, III. and IV., give the diurnal inequality in the several months and quarters of the year, as well as for winter, summer, and the entire year. The values given under each month are the arithmetic means from the data of the five years. The numerically largest maxima and minima are distinguished by heavy type. The hours are numbered continuously from midnight, so that 13 and higher numbers refer to the afternoon. The results for hour 24, being the same as for hour 0, are omitted.

A graphical illustration of the diurnal inequality for the year; for winter, for summer, for midwinter (December and January), and for midsummer (June and July), is afforded in Plate V. by the curves 1, 2, 3, 4, 5 for the declination, and by the curves 6, 7, 8, 9, 10 for the horizontal force. The curves will facilitate the comprehension of the principal phenomena. A comparison of the declination table and curves with the corresponding results at Kew during the epoch 1858–62, as given by General Sabine in the 'Phil. Trans.' for 1863, will be found of interest.

§ 8. In both tables the results proceed one figure further than the actual measurements, the extra figure arising in the process of taking the means. No smoothing process has been applied to the original data, and no correction other than the elimination of the non-cyclic element. That the results are trustworthy, as measurements of magnetic variation, to

TABLE III.—*Diurnal Inequality of Declination (after*

Hour . . .	0	1	2	3	4	5	6	7	8	9	10
January . .	−1′·36	−1′·17	−0′·86	−0′·68	−0′·69	−0′·80	−0′·84	−0′·97	−1′·34	−1′·48	−0′·33
February . .	−1·40	−1·45	−1·31	−1·15	−1·00	−1·14	−1·15	−1·43	−1·85	−1·86	−0·68
March . .	−1·07	−0·92	−0·89	−1·08	−1·39	−1·32	−1·77	−2·63	−3·74	−3·43	−1·58
April . . .	−0·71	−0·74	−0·92	−1·07	−1·36	−1·73	−2·51	−3·84	−4·91	−4·48	−2·18
May . . .	−0·83	−0·86	−1·09	−1·34	−2·07	−3·38	−4·29	−5·08	−4·75	−3·26	−0·31
June . . .	−0·45	−0·76	−0·90	−1·27	−2·10	−3·57	−4·84	−5·29	−5·12	−3·79	−1·26
July . . .	−0·66	−0·80	−1·10	−1·24	−1·99	−3·53	−4·49	−4·73	−4·77	−3·65	−1·36
August . .	−0·94	−1·10	−1·35	−1·80	−2·17	−3·03	−4·20	−5·01	−4·70	−3·06	−0·01
September .	−1·38	−1·43	−1·58	−1·96	−2·39	−2·56	−3·16	−3·85	−3·96	−2·40	+0·49
October . .	−1·48	−1·13	−1·03	−0·96	−1·10	−1·07	−1·50	−2·04	−3·05	−3·23	−1·62
November . .	−1·15	−0·82	−0·79	−0·74	−0·75	−0·95	−1·14	−1·33	−1·84	−1·93	−0·82
December . .	−1·15	−0·77	−0·46	−0·38	−0·39	−0·47	−0·74	−0·86	−1·03	−1·17	−0·14
First Quarter .	−1·28	−1·18	−1·02	−0·97	−1·03	−1·09	−1·26	−1·67	−2·31	−2·26	−0·86
Second Quarter	−0·66	−0·78	−0·97	−1·23	−1·84	−2·89	−3·88	−4·74	−4·93	−3·84	−1·25
Third Quarter .	−0·99	−1·11	−1·34	−1·67	−2·18	−3·04	−3·95	−4·53	−4·48	−3·04	−0·29
Fourth Quarter	−1·26	−0·90	−0·76	−0·69	−0·75	−0·83	−1·12	−1·41	−1·97	−2·11	−0·86
Winter . .	−1·27	−1·04	−0·89	−0·83	−0·89	−0·96	−1·19	−1·54	−2·14	−2·18	−0·86
Summer . .	−0·83	−0·95	−1·16	−1·45	−2·01	−2·97	−3·92	−4·63	−4·70	−3·44	−0·77
Year . . .	−1·05	−1·00	−1·02	−1·14	−1·45	−1·96	−2·55	−3·09	−3·42	−2·81	−0·82

TABLE IV.—$10^6 \times$ *Diurnal Inequality of Horizon*

Hour . . .	0	1	2	3	4	5	6	7	8	9	10
January . .	+ 7	+ 7	+ 7	+19	+43	+60	+58	+ 64	+ 32	− 26	− 76
February . .	+37	+23	+24	+18	+24	+44	+47	+ 63	+ 35	− 43	−110
March . .	+57	+50	+45	+42	+41	+64	+71	+ 38	− 31	−126	−195
April . . .	+79	+74	+64	+65	+62	+66	+63	+ 34	− 56	−163	−256
May . . .	+79	+75	+51	+49	+31	+19	−24	− 90	−178	−244	−260
June . . .	+65	+49	+44	+42	+37	+18	−40	−113	−183	−240	−259
July . . .	+62	+59	+38	+46	+31	+16	−33	− 90	−155	−228	−272
August . .	+75	+81	+69	+69	+62	+34	−10	− 94	−188	−268	−294
September .	+88	+82	+71	+55	+54	+40	+ 1	− 62	−156	−231	−265
October . .	+67	+57	+59	+77	+68	+82	+82	+ 50	− 20	−130	−218
November . .	+36	+36	+38	+42	+63	+79	+85	+ 65	+ 15	− 75	−154
December . .	−16	− 8	− 7	+ 3	+26	+42	+53	+ 57	+ 36	− 4	− 63
First Quarter .	+34	+26	+25	+26	+36	+56	+59	+ 55	+ 12	− 65	−127
Second Quarter .	+74	+66	+53	+52	+43	+34	− 1	− 56	−139	−216	−258
Third Quarter .	+75	+74	+59	+57	+49	+30	−14	− 82	−166	−242	−277
Fourth Quarter	+29	+28	+30	+40	+53	+68	+74	+ 57	+ 10	− 70	−145
Winter . .	+31	+27	+28	+33	+44	+62	+66	+ 56	+ 11	− 67	−136
Summer . .	+75	+70	+56	+54	+46	+32	− 7	− 69	−153	−229	−268
Year . . .	+53	+49	+42	+44	+45	+47	+29	− 6	− 71	−148	−202

units in the last place cannot, I think, be maintained for a moment; but the omission of the last figure would render it impossible to give an adequate idea of the extreme smallness of the variation during many hours of the night.

The most conspicuous feature of the declination diurnal inequality, especially in summer, is the rapid change from a maximum easterly declination, occurring from 7 to 9 A.M., to a maximum westerly declination about 1 P.M. In winter, as is apparent on inspection of the winter and midwinter curves, there is a subsidiary westerly movement during the *elimination of non-cyclic element*), + *being to west of mean.*

11	12	13	14	15	16	17	18	19	20	21	22	23
+1′·02	+2′·68	+3′·51	+3′·02	+1′·98	+1′·37	+0′·82	+0′·36	−0′·03	−0′·54	−1′·02	−1′·23	−1′·42
+1·17	+3·01	+3·76	+3·78	+3·02	+1·53	+0·83	+0·62	+0·26	−0·36	−0·77	−1·07	−1·36
+1·69	+4·66	+5·99	+5·50	+3·91	+1·70	+0·35	−0·10	−0·48	−0·55	−0·88	−1·01	−0·96
+1·27	+4·58	+6·35	+5·87	+4·12	+2·39	+1·00	+0·14	−0·25	−0·22	−0·13	−0·25	−0·44
+2·96	+5·88	+6·85	+6·16	+4·49	+2·42	+0·89	−0·08	−0·43	−0·60	−0·43	−0·38	−0·47
+1·61	+4·50	+5·95	+5·79	+4·66	+3·25	+1·84	+0·93	+0·34	+0·27	+0·18	+0·31	−0·28
+1·52	+4·38	+6·12	+6·52	+5·37	+3·23	+1·33	+0·23	−0·09	−0·09	+0·02	−0·02	−0·20
+3·36	+6·27	+7·23	+6·28	+4·49	+2·14	+0·30	−0·45	−0·30	−0·33	−0·31	−0·60	−0·71
+3·62	+5·98	+6·51	+5·40	+3·36	+1·65	+0·50	−0·00	−0·17	−0·50	−0·56	−0·61	−1·02
+1·40	+4·13	+5·28	+4·84	+3·59	+1·93	+1·12	+0·45	−0·03	−0·44	−1·14	−1·41	−1·51
+1·43	+3·18	+3·95	+3·26	+2·21	+1·40	+0·62	+0·25	−0·04	−0·59	−1·00	−1·23	−1·18
+1·06	+1·99	+2·65	+2·44	+1·90	+1·15	+0·51	+0·30	−0·12	−0·65	−1·11	−1·28	−1·32
+1·29	+3·45	+4·42	+4·10	+2·97	+1·53	+0·67	+0·29	−0·08	−0·48	−0·89	−1·10	−1·25
+1·95	+4·99	+6·39	+5·94	+4·42	+2·69	+1·24	+0·33	−0·11	−0·18	−0·13	−0·11	−0·40
+2·84	+5·54	+6·62	+6·07	+4·41	+2·34	+0·71	−0·07	−0·19	−0·31	−0·28	−0·41	−0·64
+1·30	+3·10	+3·96	+3·51	+2·57	+1·49	+0·75	+0·34	−0·06	−0·56	−1·08	−1·31	−1·34
+1·30	+3·27	+4·19	+3·81	+2·77	+1·51	+0·71	+0·31	−0·07	−0·52	−0·99	−1·20	−1·29
+2·39	+5·27	+6·50	+6·00	+4·42	+2·51	+0·98	+0·13	−0·15	−0·24	−0·20	−0·26	−0·52
+1·84	+4·27	+5·35	+4·90	+3·59	+2·01	+0·84	+0·22	−0·11	−0·38	−0·60	−0·73	−0·91

tal Force (*after elimination of non-cyclic element*).

11	12	13	14	15	16	17	18	19	20	21	22	23
−116	− 94	− 46	−22	−18	− 12	+ 3	+ 29	+ 35	+ 23	+ 15	+ 3	+ 5
−142	−126	− 84	−41	−15	− 5	+ 9	+ 32	+ 38	+ 52	+ 50	+ 37	+ 33
−206	−163	− 92	−31	+20	+ 23	+ 14	+ 43	+ 76	+ 73	+ 62	+ 59	+ 68
−274	−223	−144	−68	+ 1	+ 38	+ 70	+ 83	+106	+105	+ 97	+ 92	+ 88
−226	−155	− 87	−21	+33	+ 83	+127	+144	+152	+128	+120	+102	+ 92
−231	−150	− 82	− 7	+63	+ 86	+119	+161	+170	+146	+125	+102	+ 78
−247	−188	−113	−18	+68	+105	+138	+157	+164	+145	+127	+104	+ 85
−246	−152	− 64	+ 2	+42	+ 77	+ 95	+129	+139	+129	+129	+ 87	+ 97
−216	−105	− 21	+24	+18	+ 11	+ 35	+ 70	+ 99	+105	+108	+ 92	+103
−234	−186	−106	−52	−22	− 13	+ 31	+ 59	+ 67	+ 67	+ 75	+ 67	+ 73
−160	−146	−112	−60	−22	− 5	+ 29	+ 43	+ 57	+ 47	+ 37	+ 34	+ 28
− 85	− 78	− 44	−21	− 7	+ 4	+ 22	+ 25	+ 33	+ 20	+ 4	− 1	+ 5
−155	−128	− 74	−31	− 4	+ 2	+ 9	+ 35	+ 50	+ 49	+ 42	+ 33	+ 35
−244	−176	−104	−32	+32	+ 69	+105	+129	+143	+126	+114	+ 99	+ 86
−236	−148	− 66	+ 3	+43	+ 64	+ 89	+119	+134	+126	+121	+ 94	+ 95
−160	−137	− 87	−44	−17	− 4	+ 28	+ 43	+ 52	+ 45	+ 39	+ 34	+ 35
−157	−132	− 81	−38	−11	− 1	+ 18	+ 39	+ 51	+ 47	+ 40	+ 33	+ 35
−240	−162	− 85	−15	+37	+ 67	+ 97	+124	+138	+126	+118	+ 97	+ 90
−199	−147	− 83	−26	+13	+ 33	+ 58	+ 81	+ 95	+ 87	+ 79	+ 65	+ 63

night, entailing two unmistakable maxima of westerly declination and two of easterly in the twenty-four hours. This accords generally with conclusions I., II., III. for Dublin on pp. 175, 176 of Dr. Lloyd's 'Treatise.' His further conclusion, IV., that 'in summer the westerly movement during the night disappears,' is in more doubtful accord with the present results. The variation during the night in summer is so very slow that a definite conclusion would require the warrant of more data than are here available; but according to Table III. there is, to say the least of it, the *suspicion* of a slight secondary westerly movement in most of the summer months a few hours *before* midnight. To attain certainty in such a case one would require a very large number of observations for each month in the year. When the results of several months are grouped together, secondary maxima, unless occurring very nearly at the same hour in each month, are apt to disappear. The smoothness of the mean curve for a year or a half-year is doubtless in part due to the elimination of observational errors by means of the large number of observations included; but in some cases at least it arises from what may be termed the *suicide* of secondary phenomena. Mutual extermination of very delicate phenomena may even arise when so short a period as a month is dealt with as a unit.

If, instead of the inequality of declination, the inequality of the disturbing force perpendicular to the magnetic meridian be desired, then the results of Table III. may be converted into C.G.S. measure of force at the rate of $1'$ to 53×10^{-6} C.G.S. units.

In the horizontal force inequality the most conspicuous feature is the minimum occurring from 10 to 11 A.M. In every month there is an unmistakable maximum—especially conspicuous in summer—about 7 P.M.

In winter there is distinct evidence of a second minimum and maximum during the night and early morning, the maximum being usually the largest in the twenty-four hours. In summer the evidence in favour of a second maximum and minimum appears somewhat uncertain. The results are in general accord with the conclusions for Dublin on p. 184 of Dr. Lloyd's 'Treatise.'

Harmonic Analysis of Diurnal Inequality.

§ 9. The diurnal inequality of one of the elements, say the declination, D, can be analysed into a series such as

$$\delta D = a_1 \cos\frac{2\pi t}{24} + b_1 \sin\frac{2\pi t}{24} + \ . \ a_n \cos\frac{2\pi nt}{24} + b_n \sin\frac{2\pi nt}{24} + \ . \ . \quad (1a)$$

or

$$\delta D = c_1 \cos\frac{2\pi}{24}(t-\tau_1) + \ . \ + c_n \cos\frac{2\pi n}{24}(t-\tau_n) + \ . \ . \ . \ . \ . \quad (1b)$$

Here t is the time in hours measured from the first midnight; n is an integer; a_n, b_n, c_n, τ_n are constants, connected by the equations

$$c_n = \sqrt{a_n^2 + b_n^2} \quad . \ . \ . \ . \ . \ . \ . \quad (2)$$

$$\tau_n = \frac{24}{2\pi n}\tan^{-1}(b_n/a_n) \quad . \ . \ . \ . \ . \ . \quad (3)$$

In what follows it is arranged that c_n shall always be positive, and so τ_n is the time of the first maximum, in an algebraic sense, subsequent to midnight.

Supposing hourly values of the element known, one has twenty-three constants at one's disposal; but here I have contented myself with determining the coefficients of the terms whose periods are respectively 24, 12, 8, and 6 hours. The subsequent terms appear in reality to be very small, and any numerical results one might reach in connection with them would be of doubtful accuracy.

The following table, V., gives the values of the a, b, c coefficients for the mean diurnal inequalities of winter, summer, and the whole year.

The a, b coefficients for the 'year' are the arithmetic means of those for 'winter' and 'summer'; but as a check on the accuracy of the work they were calculated independently.

Variation to the west in the declination is regarded as positive.

TABLE V.

		a_1	b_1	c_1	a_2	b_2	c_2	a_3	b_3	c_3	a_4	b_4	c_4
δD	Winter	$-1'.55$	$-1'.17$	$1'.94$	$+0'.72$	$+1'.21$	$1'.41$	$-0'.62$	$-0'.49$	$0'.79$	$+0'.30$	$+0'.25$	$0'.39$
	Summer	−1·97	−2·59	3·26	+2·05	+1·64	2·63	−0·99	−0·61	1·16	+0·16	+0·095	0·19
	Year	−1·76	−1·88	2·58	+1·39	+1·42	1·99	−0·81	−0·55	0·98	+0·23	+0·17	0·29
$10^6 \times \delta H$	Winter	+ 68	− 3	68	−52	+11	53	+13	−22	26	+2	+15	15
	Summer	+125	−89	153	−52	+50	73	− 3	−27	27	+7	+10	13
	Year	+ 96	−46	107	−52	+31	61	+ 5	−25	25	+4	+13	13

The only change required in Table V. if time were measured from noon, instead of as throughout the present paper from midnight, would be the alteration of the *signs* of the entries referring to a_1, b_1, a_3, and b_3.

It should be explained that the calculations on which Table V. is based proceeded in every case to at least one decimal place, usually two, beyond that shown.

The table shows that in the case both of the declination and the horizontal force, the terms whose period is twenty-four hours are very much greater in summer than in winter, and the same phenomenon shows itself in the terms in the declination whose period is twelve hours. On the other hand the terms in the declination whose period is six hours appear relatively much larger in winter than in summer. It would hardly be prudent to attach too much weight to this last conclusion, in view of the extreme smallness of the quantities involved; but it is in accordance with Tables XV. and XVI. of the 'Greenwich Magnetical and Meteorological Observations' for the two years 1890 and 1891. A comparison of the other features common to these two Greenwich tables and to Table V. will be found of interest. The Greenwich tables, it should be noticed, are not confined to 'quiet' days, and in treating the horizontal force they take as unit the (1/100000) of this force at Greenwich, or, say, $10^{-8} \times 182$ C.G.S. unit.

§ 10. The number of degrees in the angles $2\pi n\tau_n/24$ is easily obtained from Table V. by means of the formula (3). Instead of giving these angles explicitly I have preferred to give the times τ_n, answering to the earliest maxima in the day of the *Westerly* declination and the horizontal force. These times are included in Table VI., along with the earliest times in the day when the several terms of the types appearing in (1_b) vanish and have their minima. The interval between successive maxima or successive minima is double that between successive zero-points, and equals the periodic time, *i.e.*, is 24, 12, 8, or 6 hours, as the case may be.

With one important exception—that of the harmonic term in the declination whose period is twenty-four hours—the first maximum of every term appears earlier in the day in summer than in winter. The difference between the corresponding times in winter and summer is

TABLE VI.

Period of term in hours		Winter			Summer			Year		
		Max.	Zero	Min.	Max.	Zero	Min.	Max.	Zero	Min.
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
24	Decln.	14 29	8 29	2 29	15 31	9 31	3 31	15 8	9 8	3 8
	H.F.	23 52	5 52	11 52	21 38	3 38	9 38	22 18	4 18	10 18
12	Decln.	1 58	4 58	7 58	1 17	4 17	7 17	1 31	4 31	7 31
	H.F.	5 36	2 36	11 36	4 32	1 32	10 32	4 59	1 59	10 59
8	Decln.	4 51	2 51	0 51	4 42	2 42	0 42	4 46	2 46	0 46
	H.F.	6 41	0 41	2 41	5 52	3 52	1 52	6 16	0 16	2 16
6	Decln.	0 40	2 10	3 40	0 30	2 0	3 30	0 37	2 7	3 37
	H.F.	1 24	2 54	4 24	0 55	2 25	3 55	1 11	2 41	4 11

conspicuously greater in the case of the horizontal force than in that of the declination.

There is, it will be noticed, a close coincidence between the time, 9 hr. 38 min., of the minimum in summer of the horizontal force term whose period is twenty-four hours and the time, 9 hr. 31 min., of the first zero in summer of the corresponding declination term. The fact, however, that no such coincidence presents itself between the corresponding times in winter would suggest the phenomenon was in part at least accidental. It can hardly be connected with the fact—shown conspicuously by Tables III. and IV., or still better by curves 1 to 10—that the time of the principal minimum of the total horizontal force inequality, from 10 to 11 A.M., is nearly coincident with a time at which the total declination inequality vanishes. Papers dealing with a theoretical connection of the sort, by Professor A. Schuster and Mr. C. Chambers, will be found in the 'Phil. Mag.' for April and May 1886, and in 'Proc. Lit. and Phil. Soc.,' Manchester, Session 1886–87, pp. 23–46.

Resultant of Cyclic Horizontal Disturbing Forces producing the Diurnal Inequality.

§ 11. The importance attaching to variations in declination suggests most naturally the resolution of the horizontal disturbing force, to which the diurnal inequalities just considered are due, into components δX and δY respectively in and perpendicular to the magnetic meridian. The preceding results show that, H denoting as usual the total horizontal force, $\delta X/H$ and $\delta Y/H$ are at most small quantities of the order 1/500.

Thus to a very close approximation we have

$$\left.\begin{aligned} \delta X &= \delta H \\ \delta Y &= H\delta D \end{aligned}\right\} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where δH and δD are the inequalities of horizontal force and declination, while H is the mean value of the horizontal force for the time under consideration.

For the mean of the years 1890–94 we have

$$H = \cdot 18211 \text{ C.G.S. units};$$

whence

$$\delta Y = 530 \times 10^{-7} \times \delta D \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

where δD is supposed to be given in minutes of arc.

Resolution in and perpendicular to the magnetic meridian is somewhat inconvenient when the general features of terrestrial magnetism are being considered, owing to the complicated relationships between the magnetic meridians at different stations. Even in dealing with the phenomena extending over a long interval of time at a single station, the reference to a set of axes whose position is continually altering has its disadvantages. When, however, the components of a force along two rectangular axes are known, the components along any other pair in the same plane are easily deduced when the inclination of the old to the new axes is given. It will thus suffice to state that for the epoch 1890–94 the mean magnetic meridian at Kew lay at 17° 36′·2 to the west of the astronomical meridian.

§ 12. Instead of giving explicitly the components in and perpendicular to the astronomical meridian I propose to consider the magnitude and direction of the resultant horizontal disturbing force itself. Denoting its intensity by ρ, its inclination to the *east* of magnetic north by ψ, we have to a sufficiently close degree of approximation

$$\rho \equiv \sqrt{(\delta X)^2 + (\delta Y)^2} = \delta H \sec \psi \quad . \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

$$\psi \equiv \tan^{-1}(-\delta Y/\delta X) = \tan^{-1}(-\delta D \,.\, H/\delta H) \quad . \quad . \quad . \qquad (7)$$

Remembering that the inclination of ρ to the astronomical north is $\psi - (17° \, 36'\cdot 2)$, it would be found a simple matter to deduce the components of the disturbing force along and perpendicular to the astronomical meridian from the calculated values of ρ and ψ.

The following table, VII., gives the values of ρ and ψ for the mean of December and January, or midwinter, the mean of June and July, or *midsummer*, and the mean for the year at each hour. The greatest and least values of ρ in each case are in heavy type.

In comparing Tables IV. and VII. the reader will require to notice that the former refers to $10^6 \, \delta H$, the latter to $10^7 \rho$. Table VII. was got out from arithmetical means proceeding to two places beyond those retained in Table IV., and an extra figure was retained in ρ, so that the arithmetical accuracy of any resolution of ρ into orthogonal coordinates should be as trustworthy as its previous resolution into δX and δY, *i.e.*, into δH and $H\delta D$.

The angle 360° is to be added to the values of ψ under the hour 23 for 'midsummer,' and for hours subsequent to 18 in 'midwinter' and 'year,' when it is desired to make out the true increase of ψ relative to a previous hour.

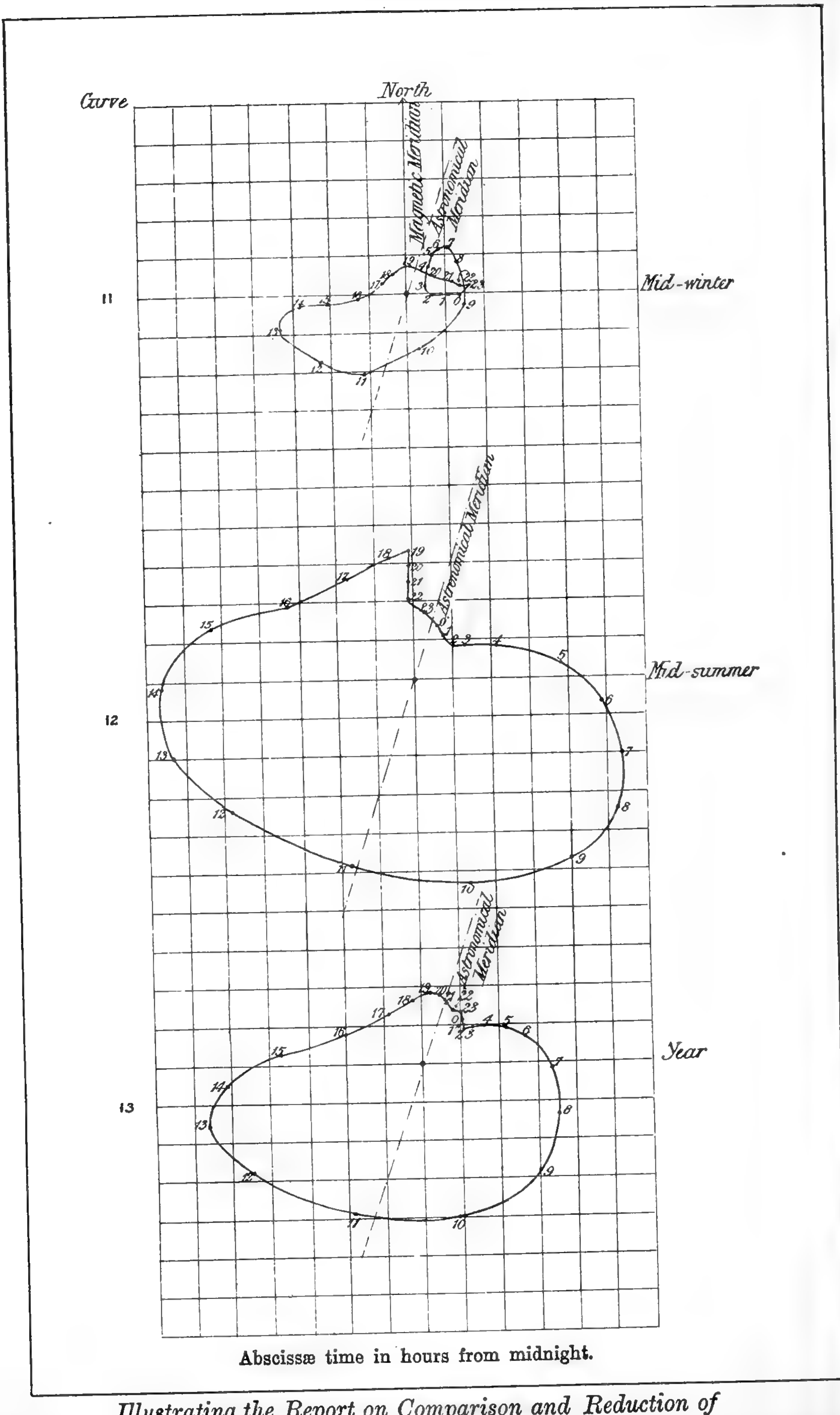
In the case of the yearly mean the vector ρ has a continuously progressive rotation from east to west through south, like the sun as seen from the earth. This is the general character of the rotation at any season; but at midwinter there is an unmistakable retrograde motion in the early morning for several hours, and at midsummer there is at least a suspicion of a retrograde motion from 8 to 10 P.M. From 10 A.M. to

Table VII.

Hour		0	1	2	3	4	5	6	7	8	9	10	11
Midwinter	$10^7 \times \rho$*	668	512	344	300	448	611	699	775	715	718	704	1,148
	ψ	93° 44′	90° 43′	90° 5′	69° 0′	39° 42′	33° 10′	36° 54′	38° 35′	61° 19′	102° 3′	169° 48′	208° 48′
Midsummer	$10^7 \times \rho$	701	679	673	797	1,135	1,887	2,500	2,842	3,119	3,058	2,743	2,532
	ψ	24° 43′	37° 24′	52° 13′	56° 53′	72° 40′	84° 48′	98° 25′	110° 53′	122° 49′	139° 51′	165° 23′	199° 9′
Year	$10^7 \times \rho$	767	717	685	746	891	1,141	1,384	1,641	1,945	2,102	2,062	2,213
	ψ	46° 21′	47° 17′	52° 19′	54° 3′	59° 33′	65° 38′	77° 43′	92° 16′	111° 20′	134° 51′	167° 54′	206° 11′

Hour		12	13	14	15	16	17	18	19	20	21	22	23
Midwinter	$10^7 \times \rho$	1,434	1,694	1,462	1,035	670	376	324	343	383	572	666	726
	ψ	233° 13′	254° 33′	261° 34′	262° 56′	266° 34′	289° 42′	327° 37′	6° 28′	55° 15′	80° 20′	88° 57′	86° 6′
Midsummer	$10^7 \times \rho$	2,896	3,343	3,271	2,736	1,964	1,536	1,618	1,673	1,455	1,259	1,034	823
	ψ	231° 20′	253° 2′	267° 51′	283° 45′	299° 2′	326° 52′	349° 4′	357° 45′	358° 9′	357° 31′	355° 40′	8° 48′
Year	$10^7 \times \rho$	2,699	2,951	2,615	1,904	1,116	730	821	949	890	850	757	791
	ψ	236° 57′	253° 40′	264° 14′	274° 0′	287° 2′	322° 15′	351° 51′	3° 33′	13° 7′	21° 47′	30° 47′	37° 19′

* The mean value of $10^7\rho$ throughout the 24 hours varies from 722 in midwinter to 1,928 in midsummer, the mean for the year being 1,390.



Illustrating the Report on Comparison and Reduction of Magnetic Observations.

2 P.M., the time of the day when the diurnal inequality is most in evidence, the value of ψ seems to vary very little with the season.

Curves whose radius vector is ρ, and vectorial angle ψ, illustrate the variations of diurnal inequality in a conspicuous way. Numerous curves of this kind, illustrating the results obtained at Greenwich for the years 1841–57, were given by Sir G. B. Airy in the 'Phil. Trans.' for 1863, and a smaller number, referring apparently to the years 1873–75, were also given by Airy in the 'Phil. Trans.' for 1885. Several applications of these curves to Dublin results appear in Dr. Lloyd's 'Treatise.' Following these examples I have drawn curves 11, 12, and 13, Plate VI., based on the results in Table VII., for midwinter, midsummer, and the whole year. The hours are stated beside the points on the curves to which they refer.

The prominent loop on the midwinter curve should be noticed. The existence of a loop on the mean winter curve and its absence in the mean summer curve for Dublin are referred to by Lloyd (*loc. cit.*, p. 187). The tendency to loops in winter months is conspicuous in Airy's Greenwich curves.

Relative Intensity of the Forces to which the Diurnal Inequality is due throughout the year.

§ 13. Without knowing the true nature of the disturbing force or forces to which the diurnal inequality is due, it is difficult to suggest any wholly satisfactory measure of intensity. Assuming the inequality to be a composite phenomenon, the counteraction of opposing forces may produce the same effect at one hour as the absence of forces at another. All the phenomena seem, however, to point to greatly increased activity of disturbing forces in summer. The data given above as to the mean values of ρ throughout the day at midwinter and midsummer make the former mean only ·374 of the latter. Evidence in the same direction is supplied by the following table VIII., which gives for each month, each quarter and half-year, and for the whole year, the sum of the hourly departures from the mean for the day, irrespective of sign, along with the *range*, or algebraical difference between the extremes. To show how comparatively little depends on how the non-cyclic element is dealt with, the table, in addition to the results obtained after the non-cyclic element has been eliminated, gives likewise the range deduced from the uncorrected data for each month. The fractions, which the table records, refer exclusively to the corrected data.

The range and the sum of the inequalities in both declination and horizontal force show a distinct minimum in December. In the declination both the range and the sum of the inequalities present an absolute maximum in August, with apparently a second, only slightly smaller maximum, in May. The variation, however, especially of the range, is so small from April to August that it would hardly be safe to conclude this was the normal phenomenon in a year of 'quiet' days. In the horizontal force there would appear to be a single maximum, whether for range or sum of inequalities, in July; but the difference between the results and those for May, June, and August is extremely small.

§ 14. These conclusions are only partly in accord with those got out by Dr. Balfour Stewart[1] for a long series of years, 1858–73, at Kew, and by Mr. W. Ellis,[2] for a still longer series of years, 1841–77, at Greenwich.

[1] *Proc. Roy. Soc.*, vol. xxvi. 1877, p. 103.
[2] *Phil. Trans.* for 1880, p. 544.

TABLE VIII.

Month	Declination					Horizontal Force in C.G.S. measure				
	Sum of Inequalities		Range			Sum of Inequalities × 10⁶		Range × 10⁶		
	Absolute value	Fraction of mean for year	Not corrected	Corrected	Fraction of mean for year	Absolute value	Fraction of mean for year	Not corrected	Corrected	Fraction of mean for year
January	29′·52	0·635	5′·22	4′·99	0·559	823	0·434	172	180	0·567
February	35′·95	0·773	5′·72	5′·64	0·632	1,132	0·598	214	205	0·642
March	47′·58	1·024	9′·78	9′·73	1·089	1,689	0·892	290	282	0·883
April	51′·45	1·107	11′·30	11′·26	1·261	2,371	1·252	386	381	1·192
May	59′·32	1·276	12′·00	11′·93	1·337	2,571	1·358	428	411	1·288
June	59′·26	1·275	11′·18	11′·25	1·259	2,610	1·378	434	429	1·342
July	57′·46	1·236	11′·18	11′·29	1·264	2,686	1·419	444	436	1·366
August	60′·14	1·294	12′·16	12′·23	1·370	2,632	1·390	450	433	1·355
September	55′·04	1·184	10′·50	10′·47	1·172	2,113	1·116	386	372	1·166
October	45′·48	0·978	8′·54	8′·52	0·954	1,964	1·037	332	317	0·991
November	32′·59	0·701	5′·92	5′·88	0·658	1,468	0·775	234	245	0·765
December	24′·03	0·517	4′·02	3′·97	0·445	664	0·351	140	142	0·445
Means:										
1st Quarter	37′·68	—	—	6′·79	—	1,215	—	—	222	—
2nd ”	56′·68	—	—	11′·48	—	2,517	—	—	407	—
3rd ”	57′·55	—	—	11′·33	—	2,477	—	—	414	—
4th ”	34′·03	—	—	6′·12	—	1,365	—	—	234	—
Winter	35′·86	—	—	6′·45	—	1,290	—	—	228	—
Summer	57′·11	—	—	11′·41	—	2,497	—	—	410	—
Year	46′·49	—	—	8′·93	—	1,893	—	—	319	—

The tables by Dr. Stewart and Mr. Ellis both give April as the month in which occurs the largest maximum in the declination range. Dr. Stewart's table gives slightly smaller, and nearly equal, maxima in June and August. In Mr. Ellis's table the mean range for August is decidedly higher than the mean for June, which latter, however, is a shade higher than the mean for May and decidedly higher than the mean for July. Again, the difference between the maximum and minimum ranges of declination in Table VIII. is much greater than in either of the other tables referred to. Thus, by Table VIII., the corrected range varies from 12′·23 to 3′·97, while in the general mean of the monthly results from the thirty-seven years included in Mr. Ellis's table the extremes are 11′·96 and 5′·78, and in Dr. Stewart's table the ratio of the maximum to the minimum monthly range is only 2 : 1.

Dr. Stewart's table is confined to declination, but Mr. Ellis gives results for the range of horizontal force as well. The general means he gives for the four months, April to July, are very nearly equal; the greatest value, that for April, being about 2 per cent. only in excess of the least of the four, that for May. The difference between the greatest and least of the mean monthly ranges of horizontal force in Mr. Ellis's table is again much less than the corresponding difference in Table VIII., the minimum, appearing in December, bearing to the April maximum the ratio 42 : 100.

The most conspicuous difference between Table VIII. and the results of Dr. Stewart and Mr. Ellis is that it shows no trace of a maximum of activity in April, and indicates markedly increased activity in August. It would, however, be precipitate to assume that the time of maximum activity falls later in the year now than in the epochs dealt with by Dr. Stewart and Mr. Ellis. The different character of the materials employed in the several cases must be borne in mind. Dr. Stewart took into account all observations except the comparatively small percentage falling under General Sabine's definition of *disturbed*, and Mr. Ellis took all but days of considerable magnetic disturbance; thus the material dealt with by both possessed presumably much greater heterogeneousness than that dealt with in Table VIII. Again, the mode in which the results were treated was different. Dr. Stewart, it is true, apparently took the means from groups of four successive years, but Mr. Ellis took the mean of the ranges deduced from each single year's records. The taking a group of years probably depresses the mean range most in those months in which the progress of the diurnal inequality is least regular.

Harmonic Analysis of Monthly Ranges.

§ 15. I have analysed into harmonic terms the quantities measuring the departures from unity of the fractions $\frac{\text{mean range for month}}{\text{mean range for year}}$ for both declination and H.F. Putting for brevity

$$x \equiv 2\pi t/12 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (8)$$

where t is time in months from the middle of January, I find for the declination

$$\frac{\text{mean range for month}}{\text{mean range for year}} - 1 = -{\cdot}40 \cos x + {\cdot}14 \sin x - {\cdot}11 \cos 2x$$
$$+ {\cdot}08 \sin 2x + {\cdot}01 \cos 3x - {\cdot}04 \sin 3x + {\cdot}01 \cos 4x + {\cdot}00 \sin 4x$$
$$+ {\cdot}04 \cos 5x - {\cdot}03 \sin 5x + {\cdot}03 \cos 6x \quad . \quad . \quad . \quad . \quad . \qquad (9)$$

for the Horizontal Force

$$\frac{\text{mean range for month}}{\text{mean range for year}} - 1 = -{\cdot}43 \cos x + {\cdot}08 \sin x - {\cdot}07 \cos 2x$$
$$+ {\cdot}03 \sin 2x + {\cdot}00 \cos 3x - {\cdot}00 \sin 3x + {\cdot}03 \cos 4x + {\cdot}03 \sin 4x$$
$$+ {\cdot}03 \cos 5x + {\cdot}01 \sin 5x + {\cdot}01 \cos 6x \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

In both cases the terms whose period is the full year are greatly predominant. There appears also in both cases an appreciable semi-annual variation; but the terms with shorter periods are very small, and little weight can be attached to their numerical measure.

Annual Variation.

§ 16. The variation of a magnetic element throughout the year, like its variation throughout a *quiet* day, is most simply regarded as composed of two parts, a uniform drift or *secular variation*, and a cyclic portion, which may be called the *annual inequality*. This is a somewhat arbitrary separation. The increase of the horizontal force, for instance, from year to year, got out from the observations of most observatories, is far from uniform; and if this be a true phenomenon the hypothesis that the secular drift is uniform throughout the whole of one year can hardly claim a physical basis. It is, however, at any rate a convenient mathematical fiction whose adoption can do no harm when its true character is explicitly recognised.

The following data are extracted from the annual Kew 'Reports':—

TABLE IX.

Year	1890	1891	1892	1893	1894
Mean Declination . .	17° 50′·6	17° 41′·9	17° 36′·7	17° 28′·8	17° 23′·0
„ H.F. . .	·18173	·18193	·18202	·18238	·18251

The mean values thence deduced for the secular variation are a decrease annually of 6′·9 in declination, and an increase annually of $10^{-6} \times 195$ C.G.S. units in horizontal force. It will be assumed that these secular variations proceed uniformly throughout the mean year, got by combining the five years 1890–94. To eliminate the secular variation one adds to the observed values $+0'{\cdot}575t$ in the case of the declination, and $-10^{-6} \times 1{\cdot}625t$ in the case of the horizontal force, t being the time elapsed in months from the middle of the mean year. Subtracting the mean value for the year from the monthly means thus corrected, one obtains the annual inequality.

§ 17. To make the true position of affairs clear, a brief explanation is necessary of how the magnetic curves are standardised at Kew. Of late years the practice has been to determine the value of the zero line for each month's curves by reference solely to the absolute observations of that month. The same instruments are used for each observation of an element, and every observation is independent of the others, except that the constant usually called P in the formula for the horizontal force—*i.e.*, the coefficient of the secondary term in the expression for the deflecting force—is determined from a whole year's observations.

One of the most probable and subtle causes of error one has to provide against in getting out an annual variation of any physical phenomenon is a possible secular or annual variation in the measuring instruments. This is especially the case with apparatus sensitive to changes of temperature. Now it is unquestionably true that the horizontal force magnetograph is affected by changes of temperature, and though the underground chamber it is worked in at Kew has a very small diurnal variation of temperature, it has a considerable annual fluctuation. Thus, however carefully temperature corrections might be determined and applied, the suspicion of an 'annual inequality' being far other than it seemed might not unreasonably be entertained, if the ultimate reference were to the magnetograph curves, either unstandardised, or standardised by reference to the mean of a year's absolute observations. It is partly to provide against this that each month's curves are referred to that one month's absolute observations.

These observations are taken about once a week and scattered over the month, so that any secular or annual variation in the *magnetographs* themselves must be very nearly eliminated.

As regards the absolute instruments there is, so to speak, no higher court of appeal. There is no obvious ground for suspicion. The horizontal force magnet has a temperature correction to apply, but this is only to allow for the difference in its temperatures at the times of the vibration and deflection experiments in the same observation. This difference in temperature is very small and very irregular, and even if the temperature correction were considerably in error the consequence could hardly be a regular annual variation, but merely an increased probable error in each individual observation.

A second source of uncertainty is that the probable error in an absolute observation and its comparison with the corresponding curve value is somewhat large compared to the annual inequality it is desired to measure.

The number of observations, some twenty, on which the mean for each month of the mean year depends may seem sufficiently large to render any mere observational error insignificant. It must be remembered, however, that on a considerable number of the days of absolute observation there proves to have been a good deal of magnetic movement. Sometimes the disturbance has been such as to render it necessary to discard the observation entirely, and in other cases there is appreciable uncertainty as to what is the true length of the curve ordinate to be taken as answering to the observed absolute value. This will be readily understood of the horizontal force, an absolute observation of which lasts usually over an hour. The result of the absolute observation is a species of mean value, to which some portions of the time occupied by the observation contribute more than others. The determinations of the declination are less subject to uncertainties of this sort ; but on the other hand the range of its annual inequality seems to bear a much smaller ratio to the secular variation than in the case of the horizontal force.

§ 18. The natural outcome of the second class of errors would obviously be a series of fictitious discontinuities in passing from one month to another of a year. As a matter of fact there did appear an unnatural amount of fluctuation in the figures obtained for the annual inequalities from the mean values answering to the middle of the months. To get rid of this I have deduced the annual inequalities in the following table, X., from a series of values, each of which is the arithmetic mean of the actually observed means of two consecutive months. These arithmetic means are attributed to the first day of the second month of the two.

The first two columns of the table give the departures from the mean for the year of the actually observed means for the individual months ; so that anyone who prefers to deduce the annual inequalities from these can easily do so.

I ought to explain that in calculating Table X. some slight differences were introduced from the declination results for 1890 published in the Kew 'Report.' The declination curves for that year had been standardised by treating as a whole the absolute observations and corresponding curve measurements throughout the year, instead of taking each month separately. I have thought it best to remove this peculiarity of treatment, referring for the purpose to the absolute observations for the year, of which, of course, the record remained.

The numerically greatest and least values in the annual inequality columns are in heavy type.

The ranges given by Table X. for the annual inequalities, viz., $1'{\cdot}22$ for the declination and $10^{-6} \times 129$ for the horizontal force, would be increased to $1'{\cdot}52$ and $10^{-6} \times 141$ respectively if the monthly means, for the middle of each month, were taken and corrected for secular variation.

§ 19. The results obtained for the annual inequalities are much smoother and more consistent than might have been expected ; but taking into account the smallness of the apparent ranges, and the fact that the

TABLE X.—*Differences from Mean for Year commencing on January* 1.

Month	Monthly means, for middle of month, uncorrected for secular variation		Results answering to first day of month after secular correction applied	
	Declination	H.F. × 10⁶	Declination	H F. × 10
January	+3′·32	−117	+0′·48	−13
February	+3·15	− 73	+0·36	−14
March	+1·68	− 86	+0·11	−15
April	+0·83	− 22	−0·47	− 5
May	+0·31	+ 48	−0·58	+46
June	−0·43	+ 66	−0·63	+74
July	−0·70	+ 27	−0·57	+47
August	−0·70	+ 55	−0·12	+24
September	−0·88	− 26	+0·36	−18
October	−2·01	+ 13	+0·28	−55
November	−2·22	+ 25	+0·18	−46
December	−2·35	+ 90	+0·59	−24

measurement of the curves proceeds only to the nearest 0′·1 in the case of the declination, and to the nearest 1×10^{-5} in the case of the horizontal force, I do not think too much confidence should be placed upon details.

The results for the annual inequality of declination show unquestionably a good *general* agreement with those deduced by General Sabine [1] from the undisturbed readings of the Kew magnetograph during the five years 1858–62. General Sabine's own paper treated each week of the mean year separately; but a summary giving mean results for the several months appears on p. 76 of Walker's 'Terrestrial and Cosmical Magnetism,' where there is an interesting discussion of the question. According to the summary, General Sabine's results made the annual inequality negative from May to August inclusive, and positive throughout the rest of the year, the range amounting to almost exactly 2′. From General Sabine's own table one would deduce a principal maximum of westerly declination in the latter half of October, with a second and only slightly smaller maximum early in December, whilst the easterly movement was conspicuously largest about the middle of July. The times at which General Sabine observed the inequality to change sign are substantially in accord with Table X.; and if the range he observed was decidedly larger, this might be associated with the fact that the secular variation during the epoch he dealt with was greater than during 1890–94. In case this agreement should be referred to identity of apparatus, it may be as well to mention that the declination magnet employed for the absolute observations at Kew of late years came into use only in the beginning of 1890.

A comparison of the declination results with those at other British stations is unfortunately by no means so reassuring. For Dublin the annual inequality got out from the mean of the years 1842–50 by Dr. Lloyd [2] makes the westerly declination *below* the mean from December to June, and gives a range exceeding 4′. There are also conspicuous differences between Table X. and the Greenwich results obtained by Sir

[1] *Phil. Trans.* for 1863, p. 292.
[2] *Treatise on Magnetism*, p. 162.

G. B. Airy [1] from the two periods 1841–47 and 1848–57. The results for these two periods, however, it must be said, differ widely between themselves, the range deduced from the first being nearly thrice that deduced from the second period.

Thinking more light desirable in the face of these discordances, I got out the annual inequality for the mean of the five years 1887–91 from the results published annually in Table XI. of the Greenwich 'Magnetical and Meteorological Observations.' Proceeding as in Table X., *i.e.* taking means for the first of each month, and applying the secular correction 6′·4 deduced from the Greenwich tables, I obtain an inequality whose resemblances to that shown in Table X. are not more conspicuous than the divergences.

The largest easterly declination appears in April–May, the largest westerly declination in September-October, and the range, 0′·6, is even smaller than in Table X. Against these comparative agreements must, however, be set the fact that the first three months of the year show an *easterly* departure from the mean.

The divergences in the results obtained for the annual inequality of declination do not, of course, necessarily imply that any of them are erroneous. The phenomena at any one station might not unnaturally present considerable variations—at least in range—from year to year; and it is conceivable that local influences may be more effective in this than in other phenomena. It has also to be borne in mind that the data employed at the several stations were selected on different principles. Still, I am doubtful whether any more definite conclusion should be drawn than that the annual inequality of declination near London is at present a very small quantity.

§ 20. The annual inequality of horizontal force shown in Table X. is, comparatively speaking, large and unmistakable; its range is a large fraction of the secular variation. In this instance there is a very fair agreement with the results given on pp. 166, 167 of Lloyd's 'Treatise' for Dublin on the mean of the years 1841–50, the most conspicuous difference being that the Dublin range was some 50 per cent. in excess of that given by Table X.

The only previous determinations, so far as I know, of the annual variation of the horizontal force at Kew are those of General Sabine [2] and Dr. Balfour Stewart,[3] for the epochs 1857–62 and 1863–68 respectively. The former found the horizontal force, corrected for secular change, to be on an average about ·00012 C.G.S. units higher in summer than in winter, while the latter found no difference. This divergence might be attributed to the epochs considered being different; but I feel considerable doubt as to the data employed having being adequate. They appear to have been in both cases simply the results of the absolute observations, uncorrected by reference either to the magnetograph curves or to the diurnal variation.

In conclusion, I have much pleasure in acknowledging my indebtedness to Mr. T. W. Baker, chief assistant, and Mr. R. S. Whipple, librarian at Kew Observatory, for explanations as to the methods of standardising the magnetic curves at Kew, and for other valuable information and assistance.

[1] *Phil. Trans.* for 1863, p. 314. [2] *Phil. Trans.* for 1863, pp. 298, 299.
[3] *Proc. Roy. Soc.*, vol. xviii. 1870, pp. 238, 239.

The Teaching of Science in Elementary Schools.—Report of the Committee, consisting of Dr. J. H. GLADSTONE (*Chairman*), Professor H. E. ARMSTRONG (*Secretary*), Professor W. R. DUNSTAN, Mr. GEORGE GLADSTONE, Sir JOHN LUBBOCK, Sir PHILIP MAGNUS, Sir H. E. ROSCOE, and Professor S. P. THOMPSON.

AT the meeting of the British Association for the Advancement of Science, held at Sheffield in 1879, a Committee was appointed with reference to the examination in the scientific specific subjects of the Code in Elementary Schools. Mr. Mundella was the first Chairman, but he was unable to continue such, as he shortly afterwards became Vice-President of the Committee of Council on Education. The Committee was re-appointed next year, with the object of reporting on the manner in which rudimentary science should be taught, as well as examined. In 1881 the Committee was again reappointed to watch and report on the working of the proposed Revised New Code, and of other legislation affecting the teaching of science in Elementary Schools. In November of that year the Committee agreed upon certain recommendations, which were adopted by the Council of the Association and transmitted to the Education Department. The Government adopted some of these recommendations in whole or in part. Since that date the Committee has been continued annually, and has regularly reported on the progress of the teaching of natural science in Elementary Schools. It has also used its influence in respect of the great question of technical instruction, the formation of school museums, Evening Continuation Schools, and other matters that have come before the Legislature. When the Royal Commission on Elementary Education was sitting, the Council of the British Association adopted a Resolution of this Committee, authorising one of its members to give evidence before the Commission, which was done accordingly. The question of the method of teaching science to classes of young children has also been considered recently, and formed part of the Report of the Committee. As the object of this Committee more directly affects those sections which deal with natural science, it was reappointed last year under the auspices of Section B.

With regard to the progress of scientific instruction in Elementary Schools, the number of departments of schools in which the following class subjects were examined by Her Majesty's Inspector during the eight years 1882 to 1890, when English was obligatory, were as follows :—

Class Subjects.—Departments	1882–83	1883–84	1884–85	1885–86	1886–87	1887–88	1888–89	1889–90
English	18,363	19,080	19,431	19,608	19,917	20,041	20,153	20,304
Geography	12,823	12,775	12,336	12,055	12,035	12,058	12,171	12,367
Elementary Science . .	48	51	45	43	39	36	36	32

The numbers during the last four years, when managers and teachers have had full liberty of choice, have been as follows :—

Class Subjects — Departments	1890–91	1891–92	1892–93	1893–94
English	19,825	18,175	17,394	17,032
Geography	12,806	13,485	14,256	15,250
Elementary Science .	173	788	1,073	1,215

It will be noticed that during the former period, while the study of English Grammar increased with the natural increase of schools, the study of scientific subjects positively decreased; but since that time, while Grammar has steadily declined, Geography and Elementary Science have increased.

The number of departments in 'schools for older scholars' for the year 1893–94 was 22,779, of which 111 did not take any class subject, leaving 22,668 as the number of departments with which the foregoing table has to deal. But it must be borne in mind that History is taken in 2,972, and Needlework (for girls) in 7,675 departments, making, with the other three subjects in the table, 44,144 in all. This shows an average of nearly two class subjects to each department. As, however, there were no less than 5,975 departments in which only one class subject was taken, it is evident that the plan of teaching one subject in the lower division of a school and another subject in the upper division, thus counting twice over in the statistical table, is largely adopted. This is further borne out by the fact that, while only two class subjects are allowed to be taken by any individual scholar, there are 4,388 departments in which three, and 197 in which four or five, of these class subjects are taught. That Elementary Science is taught in 1,215 departments must, therefore, be accepted with the reservation that, in many cases perhaps, it is only a portion of the school that gets the benefit of this instruction.

The number of scholars examined in the scientific specific subjects during the eight years 1882–90 has been as follows:—

Specific Subjects.—Children	1882–83	1883–84	1884–85	1885–86	1886–87	1887–88	1888–89	1889–90
Algebra	26,547	24,787	25,347	25,393	25,103	26,448	27,465	30,035
Euclid and Mensuration . .	1,942	2,010	1,269	1,247	995	1,006	928	977
Mechanics, A	2,042	3,174	3,527	4,844	6,315	6,961	9,524	11,453
" B	—	206	239	128	33	331	127	209
Animal Physiology . . .	22,759	22,857	20,869	18,523	17,338	16,940	15,893	15,842
Botany	3,280	2,604	2,415	1,992	1,589	1,598	1,944	1,830
Principles of Agriculture .	1,357	1,859	1,481	1,351	1,137	1,151	1,199	1,228
Chemistry	1,183	1,047	1,095	1,158	1,488	1,808	1,531	2,007
Sound, Light, and Heat . .	630	1,253	1,231	1,334	1,158	978	1,076	1,183
Magnetism and Electricity .	3,643	3,244	2,864	2,951	2,250	1,977	1,669	2,293
Domestic Economy . . .	19,582	21,458	19,437	19,556	20,716	20,787	22,064	23,094
Total	82,965	84,499	79,774	78,477	78,122	79,985	83,420	90,151
Number of scholars in Standards V., VI., and VII.	286,355	325,205	352,860	393,289	432,097	472,770	490,590	495,164

The numbers in the last column of table on p. 230 reveal a general advance; but the most marked proportional increase is to be found in the number of scholars taking Chemistry and Magnetism and Electricity. The numbers during the last four years are:—

Specific Subjects.—Children	1890–91	1891–92	1892–93	1893–94
Algebra	31,349	28,542	31,487	33,612
Euclid	870	927	1,279	1,399
Mensuration	1,489	2,802	3,762	4,018
Mechanics	15,559	18,000	20,023	21,532
Animal Physiology	15,050	13,622	14,060	15,271
Botany	2,115	1,845	1,968	2,052
Principles of Agriculture	1,231	1,085	909	1,231
Chemistry	1,847	1,935	2,387	3,043
Sound, Light, and Heat	1,085	1,163	1,168	1,175
Magnetism and Electricity	2,554	2,338	2,181	3,040
Domestic Economy	27,475	26,447	29,210	32,922
Total	100,624	98,706	108,434	119,295

With regard to the teaching of Mechanics, which has attained a development, within the last few years, far greater in proportion than any other of the scientific subjects, it is very satisfactory to note that of the 21,532 scholars above enumerated, no less than 3,407 had reached the third stage of the syllabus, while 7,296 were examined in the second stage. Considering how rapidly the elder children drop out of school after they have passed the legal Standard of exemption, these figures augur well for the value placed upon the instruction in this subject, which has become almost a speciality of the London, Liverpool, Birmingham, and some of the other large School Boards, and which is almost entirely carried on by special instructors on the peripatetic system.

The sudden rise of more than 50 per cent. in the last two years in the number of students in Chemistry does not admit of any such proportion being found in the later stages; but considerably over one-fourth of the whole were examined in the second and third stages. The recognition of the importance of experimental teaching is leading to the establishment of well-appointed laboratories by some of the School Boards, such as those of Hove and Handsworth, which can be made to serve also for the teaching of this science in the Evening Continuation Schools.

Estimating the number of scholars in Standards V., VI., and VII. at 570,000, the percentage of the number examined in these specific subjects as compared with the number of children qualified to take them is 20·9; but it should be remembered that many of the children take more than one subject for examination. The following table gives the percentage for each year since 1882:—

In 1882–83	29·0 per cent.
,, 1883–84	26·0 ,,
,, 1884–85	22·6 ,,
,, 1885–86	19·9 ,,
,, 1886–87	18·1 ,,
,, 1887–88	16·9 ,,
,, 1888–89	17·0 ,,
,, 1889–90	18·4 ,,
,, 1890–91	20·2 ,,
,, 1891–92	19·7 ,,
,, 1892–93	20·2 ,,
,, 1893–94	20·9 ,,

The returns of the Education Department given above refer to the whole of England and Wales, and are for the school years ending with August 31. The statistics of the London School Board are brought up to the year ending with Lady Day, 1895. They also illustrate the great advance that has been made in the teaching of Elementary Science as a class subject, and they give the number of children as well as the number of departments.

Years	Departments	Children
1890–91	11	2,293
1891–92	113	26,674
1892–93	156	40,208
1893–94	183	49,367
1894–95	208	52,982

The total number of departments for 'older scholars' under the London School Board at the last-named date was 820, so that in just over one-fourth of the whole the teaching of Elementary Science has been introduced into the curriculum.

The number of schools under the London School Board that are now working in accordance with the syllabus of Elementary Physics and Chemistry given in the day and evening schools Codes is steadily increasing, and the work as it becomes better understood by the teachers is naturally being better taught. About thirty schools under the Board will be engaged in this work after the summer vacation, all of which are supplied with the necessary apparatus. The old system of peripatetic experimental lectures by a demonstrator has been practically superseded in the divisions of Tower Hamlets and Hackney. The scholars are not now dependent on a brief inspection of apparatus once a fortnight or three weeks, but can use it at any opportunity given by the master of the class.

The enormous size of the classes—often 120—is, however, a serious obstacle to the success of a scheme designed to cultivate the reasoning faculties rather than the acquirement of knowledge of scientific facts and theories; in this sense it cannot be said that the scheme has yet had a fair trial. Very much depends on the individual ability and enthusiasm of the teacher, much more so than under the old system; so that in most cases the work is not satisfactorily carried on if the teacher himself has not been through the whole course practically before he begins to teach it; in fact, the Science and Art system has left its mark so deeply engraved on many teachers' minds that it takes some time to instil more modern notions into them.

The alteration in the system of inspection, though beneficial in all subjects of school curriculum, will have an especially useful effect in the teaching of science. Under the new conditions the work must be done more thoroughly, and the subjects of the syllabus evenly distributed over the year, thus preventing the rush and cram of revision in the period immediately preceding the annual examination.

The training of teachers being, as above stated, the all-important factor in securing the success of this scheme, more facilities are required for bringing together the older teachers to form normal practical classes. In considering the establishment of such classes it must be remembered that teachers, already out of their training course, give their time voluntarily after a hard day's work in school; the conditions under which such classes are held must therefore be made as easy as possible if they are to be successful, and the sympathy and enthusiasm of the teacher are to be aroused.

During the last year some fifty or sixty teachers under the London Board went through practical courses at the demonstrator's laboratory in Whitechapel, where the accommodation will soon be quite insufficient to meet the requirements of the district. Full and complete notes and suggestions were issued to all teachers attending the courses, which were much appreciated. The development of the work is largely due to the establishment of this system of normal classes.

In the meantime the question of science teaching in girls' schools has not been left unattacked. Two schools have now adopted a course of domestic science in lieu of domestic economy. A syllabus has been devised to deal as far as possible with the nature of the processes and the materials employed in the household. A short course of measurement and weighing has been introduced with the double object of familiarising the scholars with the decimal system and making them acquainted with the instruments they will have to use in accurate experimental work. The general effects of heat on matter, and their application to the work of the laundry and kitchen, are then studied; the modes of cooking and some of the simpler changes involved, chemistry of air and water, combustion, fuel, soap, hardness of water, and finally a few lessons are given on the mechanics of the household, such as the structure of taps, locks, gas fittings, hot-water boilers, flushing tanks, &c.

Classes have been held for the mistresses in this subject at the laboratory, and it is generally considered by those who have been through the course to combine mental training with the acquirement of valuable information. Except that the physiological part of the Domestic Economy is not touched, most of the important work in that syllabus which can be dealt with by scientific methods has been considered.

During the coming winter classes will be held at Berner-street Laboratory, London, E., in all stages of Elementary Natural Philosophy and Domestic Science syllabuses, but it is only too clear that this course involves commencing at the wrong end. Before any great headway is made, work of this nature must be introduced into the teachers' course of training, and to this end it is essential that teaching on the lines of the new syllabuses must be started in the Pupil Teachers' and Training Colleges.

In many parts of the country School Boards and County Councils are beginning to follow in the wake of the London Board; the subject is becoming a popular one in Evening Continuation Schools, and is often adopted as part of the elementary course for organised science schools.

The great obstacles to good science teaching at the present time in Elementary Schools are—

1. Large classes.
2. Multitude of subjects.
3. Insufficiency of the training course for teachers in science subjects.
4. Effects of the old Science and Art system, which is clearly far too formal, and pays far too little attention to ordinary requirements.

The return of the work of the Evening Continuation Schools under the Code of 1893 furnishes interesting data as to the instruction in scientific subjects in these schools. Your Committee drew attention in their Report for 1893 to the development which was taking place at that time in this direction; but pointed out that the Government return of that year did not furnish precise information on the point. A new table has been introduced this year, which gives the information desired. In the following table your Committee give the number of 'units for payment' of the grant by the Education Department for the several scientific subjects taken throughout England and Wales during the session 1893–94, to which is appended a similar return for the schools under the London School Board, extracted from the Board's Annual Report upon their Evening Continuation Schools. It may be necessary to explain that the 'unit' means a complete twelve hours of instruction received by each scholar, fractions of twelve hours not counting.

Science subjects	Units for payment	
	England and Wales	London School Board
Euclid	595	10
Algebra	3,940	316
Mensuration	14,521	279
Elementary Physiography	2,554	37
Elementary Physics and Chemistry	6,500	79
Science of Common Things	6,223	231
Chemistry	3,484	212
Mechanics	841	230
Sound, Light, and Heat	500	—
Magnetism and Electricity	2,359	662
Human Physiology	5,695	91
Botany	336	5
Agriculture	3,579	—
Horticulture	438	—
Navigation	42	—

The total number of units is (for England and Wales) 51,607, whereas the number of scholars is 41,960, indicating that about one-fourth of them must have received at least twenty-four hours of instruction. It is evident that London is far behind the country in general in the teaching of these science subjects in their Evening Continuation Schools, excepting in the matter of Mechanics and Magnetism and Electricity. The stronghold of this instruction is in Manchester and the other manufacturing districts.

It is especially interesting to note that 3,696 students took up Chemistry, and that a much larger number took the comparatively new subjects of Elementary Physics and Chemistry, and the Science of Common Things. Your Committee has already on a former occasion (1893) expressed approval of the course on Elementary Physics and Chemistry in the Evening School Code, which is a practical course intended to be carried out experimentally by the scholars themselves, and deals, not with definitions or descriptions, but with actual facts. The course on the Science of Common Things is 'a brief survey of the physical properties of bodies, serving to determine their uses and relative value.' It may be looked upon as an introduction to physical and biological science in general, and to its application to ordinary and domestic life.

In their last Report your Committee referred to the difficulties interposed by the regulations of the Code in making visits for the purposes of education to such places as Kew Gardens, the South Kensington Museum, &c., although the Science and Art Department have recognised the educational value of such attendances; and stated that Mr. Acland had favourably received a deputation on the subject, and promised increased facilities. This promise has been fulfilled; and the Code of this year provides that the time spent during school-hours in visiting museums, art galleries, and other institutions of educational value may count towards the time required for an attendance at school. Her Majesty's Inspectors are moreover instructed to encourage these visits wherever such institutions exist. It is stipulated that the teacher in charge should not have, as a rule, more than fifteen scholars with him, and that no visits should be paid unless some person competent to give information of a kind interesting to young children is present. All these regulations appear wise and proper, so that the real object of visits to these institutions may be attained; and the limitation of them to twenty in the course of the school year is not unreasonable, as, with all the other matters that demand attention, more time certainly could not well be spared.

The only other alteration of importance in the Code that concerns your Committee is the new stipulation that object lessons must be given in all schools to the children in Standards I., II., and III., and an excellent circular to Her Majesty's Inspectors has recently been issued, pointing out the true aim and nature of object teaching. It commences by drawing attention to the two kinds of instruction which are often confused: (1) observation of the object itself, and (2) giving information about the object. It dwells upon the importance of the distinction, adding, 'Object teaching leads the scholar to acquire knowledge by observation and experiment; and no instruction is properly so called unless an object is presented to the learner, so that the addition to his knowledge may be made through the senses.' It enforces the selection of subjects which can appeal to the hands and eyes of the scholars, stating that 'however well the lesson may be illustrated by diagrams, pictures, models, or lantern slides, if the children have no opportunity of handling or watching the actual object which is being dealt with, the teacher will be giving an information lesson rather than an object lesson.' . . . 'It is Elementary Science only in so far as it aids the child to observe some of the facts of nature upon which natural science is founded; but as it deals with such topics without formal arrangement, it differs widely from the systematic study of a particular science.' The circular contains many suggestions on the choice of objects; the avoidance of what is purely technical; the making of drawings or models both by teacher and children; the relation of the parts of the object to the whole; and the leading the children to describe accurately what they have seen. Several complete schemes are given for guidance in the appendix to the circular.

The Parliamentary Committee which has been considering the question of decimal weights and measures, under the chairmanship of one of your Committee, Sir Henry E. Roscoe, has just reported in favour of the permissive use of the metric system for all purposes for the next two years, after which that system should become obligatory. It recommends that it should be taught in all public schools as a necessary and integral part of Arithmetic. The Elementary School Code has, for some years past, contained a note to the effect that 'the scholars in Standards V., VI., and VII. should know the principles of the metric system,' but it has not received much attention while so much time had to be spent upon the tables of weights and measures in ordinary use. When these cease to be legal, not only will the teaching of Arithmetic be rendered more rational, but a large amount of time will be set free which can be applied to the promotion of science teaching.

Looking back over the years that have elapsed since the passing of the first Elementary Education Act, it is evident that the constant tendency has been to add to the curriculum of the schools; and some of the most recently recommended additions to the time-table include manual instruction and physical exercises. The difficulty of finding time for these has led to the suggestion that the generally recognised hours of schooling might be extended in the case of the elder scholars. This course would involve some practical inconveniences; and in view of the fact that the children pass their Standards now at an earlier and more immature age than they did some years ago, it is a question worth consideration whether the time has not arrived when the recognised school age should be raised from thirteen to fourteen, and the work of the Standards made to spread over this extended period. Such an arrangement would have the manifest advantage of affording a broader and more practical education, without over-pressure to either the teachers or the taught.

Quantitative Analysis by means of Electrolysis.—Second Report of the Committee, consisting of Professor J. EMERSON REYNOLDS (*Chairman*), Dr. C. A. KOHN (*Secretary*), Professor P. FRANKLAND, Professor F. CLOWES, Dr. HUGH MARSHALL, Mr. A. E. FLETCHER, Mr. D. H. NAGEL, Mr. T. TURNER, *and* Mr. J. B. COLEMAN.

A PRELIMINARY report was furnished by the Committee last year in which the contemplated plan of work was outlined.

The bibliography of the subject has been completed and is appended.

The experimental work has been carefully organised, and the results on the determination of bismuth and of tin are nearly complete. Other work is in progress, but the Committee prefer to hold over these results until next year in order that they may be added to and may include methods of separation of some of the metals.

Considerable attention has been given to the choice and arrangement of the special apparatus required. A detailed description of the arrangements adopted will be given in the next report.

As the bibliography is completed, the Committee propose to devote their attention during the coming year exclusively to experimental inquiries.

Bibliography on Methods of Quantitative Analysis by means of Electrolysis.

The bibliography has been compiled from the following journals, and is complete up to the end of 1894:—

	Journal	Period abstracted	Abbreviation
1	Journal of the Chemical Society	1847–1894	J. Chem. Soc.
2	Journal of the Society of Chemical Industry	1882–1894	J. Soc. Chem. Ind.
3	Chemical News	1860–1894	Chem. News.
4	American Chemical Journal	1878–1894	Amer. Chem. J.
5	Journal of Analytical and Applied Chemistry	1887–1894	J. Analyt. & App. Chem.
6	Journal of the American Chemical Society	1879–1894	J. Amer. Chem. Soc.
7	Zeitschrift für analytische Chemie	1862–1894	Zeits. anal. Chem.
8	Berichte der deutschen chemischen Gesellschaft	1868–1894	Ber.
9	Zeitschrift für anorganische Chemie	1892–1894	Zeits. anorg. Chem.
10	Zeitschrift für physikalische Chemie	1887–1894	Zeits. phys. Chem.
11	Zeitschrift für Electrochemie (Organ der deutschen electrochemischen Gesellschaft)	1894	Zeits. Electrochem.

References to papers of importance published in journals other than the above are also included, viz. :—

Journal	Abbreviation
American Chemist	Amer. Chem.
Annales de Chimie et Physique	Annales Chim. et Phys.
Berg- u. hüttenmännische Zeitung	Berg- u. hütten. Zeit.
Bulletin de la Société Chimique	Bull. Soc. Chim.
Chemiker-Zeitung	Chem.-Zeit.
Comptes Rendus	Compt. Rend.
Dingler's Polytechnisches Journal	Dingler Polyt. J.
Jahresbericht der Chemie	Jahresber. Chem.
Journal of the Franklin Institute	J. Franklin Inst.
Journal für praktische Chemie	J. prakt. Chem.
Monatshefte für Chemie	Monatsh. Chem.
Pharmaceutische Central-Halle	Pharm. Central-Halle.
Repertorium der analytischen Chemie	Rep. anal. Chem.
Zeitschrift für angewandte Chemie	Zeits. angew. Chem.

Books of Reference.

1. 'Quantitative Analyse durch Electrolyse.' A. Classen. 3rd edit., 1892. Published by J. Springer, Berlin.

Translation, by W. H. Herrick, of 2nd edition, 1887, 'Quantitative Chemical Analysis by Electrolysis.' Published by I. Wiley, New York.

2. 'Electro-chemical Analysis.' Edgar F. Smith. 1890. Published by P. Blakiston, Philadelphia.

Arrangement of Bibliography.

The bibliography is divided into the following sections :—

I. General conditions for electrolytic analysis.

II. Special apparatus employed.

III. Quantitative methods, for the determination of metals by means of electrolysis.

IV. Quantitative methods, for the separation of metals by means of electrolysis.

V. Special applications of electrolysis in quantitative analysis.

VI. Applications of electrolysis to qualitative analysis (including sundry papers bearing on electrolytic analysis).

I. *General Conditions for Electrolytic Analysis.*

Author	Journal	Year	Volume	Page	Summary of Contents
Classen, A.	Ber.	1894	27	2060	Importance of measurement of current density.
Freudenberg, H.	Ber.	1892	25	2492	Importance of electromotive force for electrolytic separations. (Preliminary paper.)
Freudenberg, H.	Zeits phys. Chem.	1893	12	97	Importance of electromotive force for electrolytic separations.
Oettel, F.	Chem.-Zeit.	1893	17	173	Importance of measurement of current density.
Sloane, T. O'Connor	J. Amer. Chem. Soc.	1891	13	140	Importance of measurement of current density and of electromotive force.
Smith, E. F.	J. Amer. Chem. Soc.	1894	16	93	Critique on Freudenberg's paper.
	Zeits. anorg. Chem.	1894	6	40	
Thomälen, H.	Chem.-Zeit.	1894	18	1121	Importance of measurement of strength of current.

II. *Special Apparatus employed.*

Author	Journal	Year	Volume	Page	Apparatus described
Classen, A.	Ber.	1884	17	2467	Siemens' magneto-electric machine.
Classen, A.	Ber.	1885	18	1104	Meidinger and Bunsen batteries. Liquid resistance. Rheostat.
Classen, A.	Ber.	1885	18	1787	General application of secondary batteries.
Classen, A.	Ber.	1888	21	359	Rheostat. Voltameter. Electrodes and stand.
Classen, A., and Schelle, R.	Ber.	1888	21	2892	Accumulators. Voltameter.
Classen, A.	Ber.	1894	27	163	Sand-blasted platinum dishes.
Classen, A.	Ber.	1894	27	2060	Ammeter. Voltameter. Arrangement of circuit.
Eislebener Laboratorium	Berg- u. hütten. Zeit.	1875	34	155	Clamond thermopile.
Eislebener Laboratorium	Zeits. anal. Chem.	1876	15	333	Clamond thermopile.
Foote, H. C.	Amer. Chem. J.	1884	6	333	Electrodes. Arrangement of circuit.

Special Apparatus employed—continued.

Author	Journal	Year	Volume	Page	Apparatus described
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Galvanometer. Rheostat. Electrodes. Gülcher thermopile.
Herrick, W. H.	J. Analyt. & App. Chem.	1888	2	67	Stand for electrodes.
Klobukow, N. von	J. prakt. Chem.	1886	33	473	Stand for electrodes. Micro-burner.
Klobukow, N. von.	J. prakt. Chem.	1886	34	539	Rheostat. Ammeter. Arrangement of circuit.
Klobukow, N. von.	J. prakt. Chem.	1888	37	375	Rheostat. Stand for electrodes.
Klobukow, N. von.	J. prakt. Chem.	1889	40	121	Stirrer for electrolyte.
Kohn, C.A., and Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Arrangement of circuit.
Levoir, L. C.	Zeits. anal. Chem.	1889	18	63	Electrodes and stand.
Luckow, C.	Zeits. anal. Chem.	1869	8	23	Meidinger batteries. Electrodes and stand.
Malapert, R. von	Zeits. anal. Chem.	1887	16	56	Stand for electrodes.
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Modified Meidinger batteries. Electrodes.
Meeker, G. H.	J. Analyt. & App. Chem.	1892	6	267	Stand for electrodes.
Nüssenson, H., and Rüst, C.	Zeits. angew. Chem.	1892	—	451	Meidinger and secondary batteries.
Nüssenson, H., and Rüst, C.	Zeits. anal. Chem.	1893	22	424	Meidinger and secondary batteries. Arrangement of circuit. Ammeter. Voltameter.
Ohl, W.	Zeits. anal. Chem.	1879	18	523	Sine galvanometer.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Meidinger batteries. Electrodes.
Stillwell, J.S., & Austen, P.T.	J. Analyt. & App. Chem.	1892	6	129	Utilisation of electric light current for electrolytic analysis.
Thomälen, H.	Chem.-Zeit.	1894	18	1121	Meidinger and secondary batteries.
Vortmann, G.	Monatsh. Chem.	1893	14	536	Secondary batteries. Electrodes. Rheostat. Galvanometer. Arrangement of circuit.
Wolff, C. H.	Zeits. angew. Chem.	1888	—	296	Voltameter.

III *Quantitative Methods for the Determination of Metals by means of Electrolysis.*

The methods for the following metals are given :—

1. Antimony.	5. Cobalt.	9. Iron.	13. Molybdenum.	17. Rhodium.	21. Thallium.
2. Arsenic.	6. Copper.	10. Lead.	14. Nickel.	18. Selenium.	22. Tin.
3. Bismuth.	7. Gold.	11. Manganese.	15. Palladium.	19. Silver.	23. Uranium.
4. Cadmium.	8. Indium.	12. Mercury.	16. Platinum.	20. Tellurium.	24. Zinc.

NOTE I.—Under the heading 'Composition of Electrolyte,' the substance or substances added to a neutral solution of a salt of the metal referred to are included.

NOTE II.—The metal is deposited as such, except when otherwise stated (*in italics*).

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		1. ANTIMONY.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium carbonate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Potassium oxalate. Alkali tartrate. Ammonium sulphide.
Classen, A.	Ber.	1881	17	2467	Sodium sulphide. Sodium or potassium sulphhydrate.
Classen, A., and Ludwig, R.	Ber.	1885	18	1104	Sodium sulphide.
Classen, A.	Ber.	1894	27	2060	Sodium sulphide.
Kohn, C. A., and Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Sodium sulphide.
Lecrenier, A.	Chem.-Zeit.	1889	13	1219	Sodium sulphide.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Hydrochloric acid. Alkali sulphide.
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem.	1879	18	587	Ammonium tartrate. Alkali sulphide.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Sodium sulphide.
Vortmann, G.	Ber.	1891	24	2749	Sodium sulphide and sodium hydrate; *as amalgam.*

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		2. Arsenic.			
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Hydrochloric acid; *as hydride.* Oxalic acid; *partly as metal.*
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Hydrochloric acid; *partly as metal and partly as hydride.*
Moore, T.	Chem. News.	1886	53	209	Acid solution and zinc sulphate; *as hydride.*
Vortmann, G.	Ber.	1891	24	2749	Hydrochloric acid and potassium iodide; *as amalgam.*
		3. Bismuth.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate, ammonium carbonate, and ammonium oxalate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Ammonium oxalate and nitric acid.
Classen, A., and Ludwig, R.	Ber.	1886	19	323	Potassium and ammonium oxalates.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Sulphuric acid.
Luckow, C.	Dingler Polyt. J.	1864	178	42	Sulphuric acid.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Nitric acid.
Moore, T.	Chem. News.	1886	53	209	Phosphoric acid
Rüdorff, F.	Zeits. angew. Chem.	1892	—	198	Sodium pyrophosphate, potassium oxalate, and potassium sulphate.
Smith, E. F., & Knerr, E. B.	Amer. Chem. J.	1885	8	206	Sulphuric acid.
Smith, E. F., & Saltar, J. B.	J. Analyt. & App. Chem	1893	7	128	Nitric acid.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Sodium pyrophosphate, potassium oxalate, and sulphate.
Thomas, N. W., and Smith, E. F.	Amer. Chem. J.	1883	5	114	Sulphuric acid. Citric acid and sodium hydrate. Citric acid.
Vortmann, G.	Ber.	1891	24	2749	Hydrochloric acid and potassium iodide; *as amalgam.* Hydrochloric acid and alcohol; *as amalgam.* Nitric and tartaric acids; *as amalgam.* Ammonium hydrate and tartaric acid; *as amalgam.*
Wieland, J.	Ber.	1884	17	1611	Oxalic acid. Nitric acid.

4. Cadmium.

Beilstein, F., and Jawein, J.	Ber.	1879	12	759	Potassium cyanide.
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium hydrate.
Clarke, F. W.	Ber.	1878	11	1409	Ammonium hydrate.
	Zeits. anal. Chem.	1879	18	103	
Classen, A., and Reis, M.A.	Ber.	1881	14	1622	Ammonium oxalate.
Classen, A.	Ber.	1884	17	2467	Ammonium oxalate.
Classen, A.	Ber.	1894	27	2060	Ammonium oxalate and oxalic acid.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Potassium cyanide. Ammonium sulphate and sulphuric acid.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Neutral salt. Neutral salt and ammonium hydrate. Neutral salt and sodium acetate.
Moore, T.	Chem. News	1886	53	209	Phosphoric acid.
Muspratt, M.	J. Soc. Chem. Ind.	1894	13	211	Potassium cyanide. Sulphuric acid. Ammonium oxalate.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Potassium cyanide.
Smith, E. F.	Ber.	1878	11	2048	Neutral acetate.
	Zeits. anal. Chem.	1879	18	263	
Smith, E. F.	Amer. Chem. J.	1880	2	41	Sodium acetate. Sulphuric acid.
Smith, E. F.	Amer. Chem. J.	1890	12	329	Sodium phosphate and phosphoric acid.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Potassium cyanide.
Vortmann, G.	Ber.	1891	24	2749	Ammonium oxalate; *as amalgam.* Tartaric acid and ammonium hydrate; *as amalgam.*
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Formate and formic acid.
Wieland, J.	Ber.	1884	17	1611	Oxalic acid. Potassium cyanide. Sulphuric acid.
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Sulphuric acid.

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		5. Cobalt.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Potassium oxalate. Ammonium oxalate.
Classen, A.	Ber.	1894	27	2060	Ammonium oxalate.
Fresenius, H., & Bergmann, F.	Zeits. anal. Chem.	1880	19	312	Ammonium sulphate and hydrate. Sodium phosphate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Ammonium hydrate. Ammonium oxalate.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Ammonium oxalate. Ammonium sulphate and hydrate.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Alkali acetate, tartrate, or citrate. Ammonium hydrate. Potassium cyanide.
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Ammonium hydrate.
Moore, T.	Chem. News.	1886	53	209	Phosphoric acid.
Ohl, W.	Zeits. anal. Chem.	1879	18	523	Ammonium hydrate.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Ammonium sulphate and hydrate.
Schweder, E. P.	Zeits. anal. Chem.	1877	16	344	Ammonium sulphate and hydrate.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Ammonium sulphate and hydrate.
Vortmann, G.	Monatsh. Chem.	1893	14	536	Alkali tartrate, sodium hydrate, and potassium iodide.
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Ammonium hydrate.
		6. Copper.			
Boisbaudran, Lecoq de	Zeits. anal. Chem.	1868	7	253	Sulphuric acid.
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Ammonium oxalate.
Classen, A.	Ber.	1884	17	2467	Ammonium oxalate. Sulphuric acid.
Classen, A.	Ber.	1885	18	1787	Ammonium oxalate.
Classen, A., and Schelle, R.	Ber.	1888	21	2892	Acid ammonium oxalate.

Classen, A.	Ber.	1894	27	2060	Ammonium oxalate.
Croasdale, F.	J. Analyt. & App. Chem.	1891	5	133	Sulphuric acid.
Drossbach, G. P.	Chem.-Zeit.	1892	16	818	Ammonium hydrate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Ammonium oxalate. Sulphuric acid.
Gibbs, W.	Zeits. anal. Chem.	1863	2	334	Sulphate.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Hampe, W.	Zeits. anal. Chem.	1874	13	176	Nitric acid.
Herpin	Zeits. anal. Chem.	1876	15	335	Sulphuric acid.
Luckow, C.	Dingler Polyt. J.	1864	177	296	Sulphuric acid.
Luckow, C.	Zeits. anal. Chem.	1869	8	23	Nitric acid.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Nitric, sulphuric, or acetic acid. Hydrochloric acid and ammonium chloride, sodium chloride or sodium acetate. Ammonium hydrate. Ammonium carbonate. Potassium cyanide.
Luckow, C.	Chem.-Zeit.	1882	6	23 43	Nitric and tartaric acids.
Macintosh, J. B.	Amer. Chem. J.	1881	3	354	Nitric and citric acids. Nitric and tartaric acids. Sulphuric acid.
Macintosh, J. B.	Chem.-Zeit.	1882	6	282	Nitric acid.
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Nitric acid.
Moore, T.	Chem. News.	1886	53	209	Potassium cyanide and ammonium carbonate.
Oettel, F.	Zeits. anal. Chem.	1888	27	15	Nitric acid.
Oettel, F.	Chem.-Zeit.	1894	18	879	Ammonium nitrate and hydrate.
Oeschger and Mesdach	Bull. Soc. Chim.	1875	23	180	Nitric acid.
Ohl, W.	Zeits. anal Chem.	1879	18	523	Nitric acid.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Nitric acid. Sulphuric acid.
Rüdorff, F.	Ber	1888	21	3050	Potassium nitrate and ammonium hydrate. Ammonium nitrate and hydrate.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Nitric acid.
Smith, E. F.	Amer. Chem. J.	1890	12	329	Sodium phosphate and phosphoric acid.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Stahl, W.	Dingler Polyt. J.	1886	262	277	Nitric acid.

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		COPPER—*continued.*			
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Nitric acid. Sulphuric acid. Ammonium nitrate and hydrate.
Ullgren, C.	Zeits. anal. Chem.	1868	7	442	Sulphuric acid.
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Formate and formic acid.
Westmoreland, J. W.	J. Soc. Chem. Ind.	1886	5	48, 277	Sulphuric acid.
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Nitric acid.
		7. GOLD.			
Frankel, L. K.	J. Franklin Inst.	1891	101	141	Ammonium thiocyanate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Chloride. Potassium cyanide.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Potassium cyanide.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	695	Potassium cyanide.
Smith, E. F.	J. Analyt. & App. Chem.	1891	5	204	Chloride. Sodium sulphide.
Smith, E. F.	Amer. Chem. J.	1891	13	206	Sodium phosphate and phosphoric acid.
Smith, E. F.	Ber.	1891	24	2175	Potassium cyanide.
	Amer. Chem. J.	1891	13	417	
		8. INDIUM.			
Schucht, L.	Zeits. anal. Chem.	1883	22	241	Sulphuric acid.
		9. IRON.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium carbonate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Ammonium oxalate.
Classen, A.	Ber.	1894	27	2060	Potassium and ammonium oxalates.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Kohn, C. A., and Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Potassium and ammonium oxalates.

Luckow, C.	Zeits. anal. Chem	1880	19	1	Ammonium citrate and citric acid.
Moore, T.	Chem. News	1886	53	209	Phosphoric acid.
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem.	1879	18	587	Acid ammonium oxalate.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	197	Ammonium oxalate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Ammonium oxalate.
Smith, E. F.	Amer. Chem. J.	1888	10	330	Sodium citrate.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Vortmann, G.	Monatsh. Chem.	1893	14	536	Sodium potassium tartrate and sodium hydrate.

10. Lead.

Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and nitric acid; *as metal.* Sodium pyrophosphate and tartaric acid; *as metal.*
Classen, A., and Reis, M.A.	Ber.	1881	14	1622	Ammonium oxalate; as *metal.* Nitric acid; *as oxide.*
Classen, A.	Ber.	1894	27	163	Nitric acid; *as oxide.*
Classen, A.	Ber.	1894	27	2060	Nitric acid; *as oxide.*
Kiliani, M.	Berg- u. hütten. Zeit.	1883	42	253	Neutral acetate; *as metal.* Sodium chloride; *as metal.*
Kreichgauer, A.	Ber.	1894	27	315	Nitric acid; *as oxide.*
Luckow, C.	Dingler Polyt. J.	1864	178	42	Sulphuric acid; *as oxide.*
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Neutral acetate; *as metal.* Nitric acid; *as oxide.*
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Nitric acid; *as oxide.*
May, W. C.	Zeits. anal. Chem.	1875	14	347	Nitric acid; *as oxide.*
Medicus, L.	Ber.	1892	25	2490	Carbonate and nitric acid; *as oxide.*
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem.	1877	16	469	Tartrate and alkali acetate; *as metal.*
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem.	1879	18	587	Sodium tartrate, sodium hydrate, and ammonium hydrate; *as metal.*
Riché, A.	Compt. Rend.	1877	85	226	Nitric acid; *as oxide.*
Riché, A.	Annales Chim. et Phys.	1882	13	508	Nitric acid; *as oxide.* Nitric and oxalic acids; *as metal.*
Rüdorff, F.	Zeits. angew. Chem.	1892	—	197	Nitric acid and copper nitrate; *as oxide.*
Schiff, H.	Ber.	1877	10	1098	Sodium hydrate; *as metal.*
Schucht, L.	Zeits. anal. Chem.	1883	22	241	Nitric acid; *as oxide.*
Tenney, F.	Amer. Chem. J.	1883	5	413	Nitric acid; *as oxide.*
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Nitric acid and copper nitrate; *as oxide.*

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		LEAD—*continued.*			
Vortmann, G.	Ber.	1891	24	2749	Sodium acetate, potassium nitrite, and acetic acid; *as amalgam.* Tartaric acid, sodium hydrate, and potassium iodide; *as amalgam.*
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Formate and formic acid; *partly as metal, partly as oxide.*
Wieland, J.	Ber.	1884	17	1611	Nitric acid; *as oxide.*
		11. MANGANESE.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium hydrate; *as oxide.*
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Potassium and ammonium oxalates; *as oxide.* Nitric acid; *as oxide.*
Classen, A.	Ber.	1884	17	2351	Potassium oxalate; *as oxide.*
Classen, A.	Ber.	1894	27	2060	Acetic acid; *as oxide.*
Luckow, C.	Dingler Polyt. J.	1864	178	42	Sulphuric acid; *as oxide.*
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Nitric acid; *as oxide.*
Moore, T.	Chem. News	1886	53	209	Nitric acid; *as oxide.* Ammonium thiocyanate; *as metal.*
Riché, A.	Compt. Rend.	1877	85	226	Sulphuric acid; *as oxide.* Nitric acid; *as oxide.*
Riché, A.	Annales Chim. et Phys.	1882	13	508	Sulphuric acid; *as oxide.*
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Sulphuric acid; *as oxide.*
Schucht, L.	Zeits. anal. Chem.	1883	22	485	Nitric acid; *as oxide.*
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Sulphuric acid; *as oxide.*
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Formate and formic acid; *as oxide.*
Wieland, J.	Ber.	1884	17	1611	Ammonium oxalate; *as oxide.* Sulphuric acid; *as oxide.*
		12. MERCURY.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium hydrate.
Clark, F. W.	Zeits. anal. Chem.	1879	18	103	Sulphuric acid.

Classen, A., and Ludwig, R.	Ber.	1886	19	323	Nitric acid.
Classen, A.	Ber.	1894	27	2060	Ammonium oxalate.
Escosura, L. de	Zeits. anal. Chem.	1886	25	404	Hydrochloric acid and ammonium sulphite.
	Chem. News	1886	53	249	
Frankel, L. K.	J. Franklin Inst.	1891	101	141	Ammonium thiocyanate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Nitric acid. Potassium cyanide.
Hannay, J. B.	J. Chem. Soc.	1873	26	568	Mercuric sulphate. Mercurous nitrate and nitric acid. Mercuric chloride and potassium cyanide.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Neutral salts.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Nitric acid. Sulphuric acid. Tartaric acid and ammonium hydrate. Potassium cyanide. Sodium pyrophosphate and ammonium hydrate.
Smith, E. F., and Knerr, E. B.	Amer. Chem. J.	1885	8	206	Nitric acid.
Smith, E. F., and Frankel, L. K.	Amer. Chem. J.	1889	11	264	Potassium cyanide.
	J. Analyt. & App. Chem.	1889	3	254	
Smith, E. F.	J. Analyt. & App. Chem.	1891	5	202	Sodium sulphide.
Smith, E. F., and Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	185	Nitric acid.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Nitric acid. Tartaric acid and ammonium hydrate. Nitric acid, sodium pyrophosphate, and ammonium hydrate.
Vortmann, G.	Ber.	1891	24	2749	Ammonium oxalate. Tartaric acid and ammonium hydrate. Sodium sulphide and hydrate. Mercuric chloride and potassium iodide.

13. Molybdenum.

Schucht, L.	Zeits. anal. Chem.	1883	22	241	Alkali molybdate; *as oxide.*
Smith, E. F., and Hoskinson, W. S.	Amer. Chem. J.	1885	8	90	Neutral or acid solution; *as oxide.*

14. Nickel.

Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Ammonium oxalate.

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		NICKEL—*continued*.			
Classen, A.	Ber.	1894	27	2060	Ammonium oxalate.
Fresenius, H., and Bergmann, F.	Zeits. anal. Chem.	1880	19	314	Ammonium sulphate and hydrate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Ammonium hydrate. Ammonium oxalate.
Gibbs, W.	Zeits. anal. Chem.	1863	2	334	Ammonium hydrate.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Herpin	Zeits. anal. Chem.	1876	15	335	Ammonium hydrate.
Kohn, C. A., and Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Ammonium oxalate. Ammonium sulphate and hydrate. Potassium cyanide.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Alkali acetate, tartrate, or citrate. Ammonium hydrate. Potassium cyanide.
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Ammonium hydrate.
Moore, T.	Chem. News	1886	53	209	Phosphoric acid.
Oettel, F.	Zeits. Electrochem.	1894	1	196	Ammonium sulphate and hydrate.
Ohl, W.	Zeits. anal. Chem.	1879	18	523	Ammonium hydrate.
Riché, A.	Compt. Rend.	1877	85	226	Ammonium hydrate.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Sulphuric acid.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	3	Ammonium sulphate and hydrate. Sodium pyrophosphate.
Rüdorff, F.	Zeits. angew. Chem.	1894	—	388	Sodium sulphate and ammonium hydrate.
Schweder, E. P.	Zeits. anal. Chem.	1877	16	344	Ammonium sulphate and hydrate.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Ammonium sulphate and hydrate.
Vortmann, G.	Monatsh. Chem.	1893	14	536	Alkali cyanide; *as hydrate.*
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Ammonium hydrate.
		15. PALLADIUM.			
Schucht, L.	Zeits. anal. Chem.	1883	22	241	Nitrate and nitric acid. Excess of alkali hydrate.
Smith, E.F., and Keller, H.F.	Amer. Chem. J.	1890	12	212	Ammonium chloride and hydrate.
Smith, E. F.	Amer. Chem. J.	1891	13	206	Sodium phosphate and phosphoric acid.

16. Platinum.					
Classen, A.	Ber.	1884	17	2464	Hydrochloric acid. Sulphuric acid. Ammonium oxalate. Potassium oxalate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Hydrochloric acid. Potassium cyanide.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Sodium chloride.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	695	Sulphuric acid.
Smith, E. F.	Amer. Chem. J.	1891	13	206	Sodium phosphate and phosphoric acid.
17. Rhodium.					
Joly, A., and Leiché, E.	Compt. Rend.	1891	112	793	Sulphate or chloride.
Smith, E. F.	J. Analyt. & App. Chem.	1891	5	201	Sodium chloride and potassium cyanide. Sodium chloride, sodium phosphate, and phosphoric acid.
18. Selenium.					
Schucht, L.	Zeits. anal. Chem.	1883	22	241	Acid or alkaline solution in presence of c pper salt.
Schucht, L.	Zeits. anal. Chem.	1883	22	483	Acid or alkaline solution.
19. Silver.					
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and nitric acid.
Classen, A.	Ber.	1894	27	2060	Potassium cyanide.
Fresenius, H. & Bergmann, F.	Zeits. anal. Chem.	1880	19	324	Nitric acid.
Krutwig, J.	Ber.	1882	15	1267	Ammonium sulphate and hydrate.
Luckow, C.	Dingler Polyt. J.	1864	178	42	Sulphuric acid.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Nitric acid. Potassium cyanide.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	2	Potassium cyanide. Ammonium sulphate and hydrate.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1889	11	264	Potassium cyanide.
Smith, E. F.	Amer. Chem. J.	1890	12	329	Sodium phosphate and ammonium hydrate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Potassium cyanide.

Quantitative Methods for the Determination of Metals by means of Electrolysis—continued.

Author	Journal	Year	Volume	Page	Composition of Electrolyte
		20. Tellurium.			
Schucht, L.	Zeits. anal. Chem.	1883	22	241 485	Acid or alkaline solution.
		21. Thallium.			
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and sulphuric acid.
Neumann	Ber.	1888	21	356	Ammonium oxalate.
Schucht, L.	Zeits. anal. Chem.	1883	22	241	Ammonium or potassium hydrate; *partly as metal and partly as oxide.*
		22. Tin.			
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Hydrochloric acid. Ammonium oxalate.
Classen, A.	Ber.	1884	17	2467	Ammonium sulphide.
Classen, A.	Ber.	1894	27	2060	Acid ammonium oxalate. Ammonium oxalate and acetic acid.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Ammonium oxalate.
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Ammonium oxalate.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Hydrochloric acid. Alkali sulphide.
Moore, T.	Chem. News	1886	53	209	Phosphoric acid.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	197	Acid ammonium oxalate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Acid ammonium oxalate.
		23. Uranium.			
Smith, E. F.	Amer. Chem. J. Ber.	1879 1880	1 13	329 751	Sodium, potassium, or barium acetate; *as oxide.* Sodium formate; *as oxide.*

24. Zinc.

Beilstein, A., and Jawein, J.	Ber.	1879	12	446	Potassium cyanide.
Brand, A.	Zeits. anal. Chem.	1889	28	581	Sodium pyrophosphate and ammonium carbonate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Ammonium oxalate.
Classen, A.	Ber.	1894	27	2060	Ammonium oxalate and tartaric acid. Potassium oxalate and tartaric acid.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Sulphate; *as amalgam.*
Kohn, C. A., and Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Ammonium oxalate. Ammonium sulphate and hydrate.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Alkali acetate, tartrate, or citrate. Ammonium hydrate. Potassium cyanide.
Luckow, C.	Chem. Zeit.	1885	9	338	Hydrochloric acid; *as amalgam.* Sulphuric acid; *as amalgam.*
Millot, A.	Bull. Soc. Chim.	1877	32	482	Potassium cyanide.
Millot, A.	Bull. Soc. Chim.	1882	37	339	Alkali hydrate.
Moore, T.	Chem. News	1886	53	209	Phosphoric acid. Sodium phosphate, ammonium carbonate, and potassium cyanide.
Nahnsen, G.	Berg- u. hütten. Zeit.	1891	—	393	Sulphuric acid.
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem.	1877	16	469	Ammonium acetate.
Parodi, G., and Mascazzini, A.	Zeits. anal. Chem. Ber.	1879 1877	18 10	587 1098	Ammonium acetate and citric acid.
Reinhardt and Ihle	J. prakt. Chem.	1881	24	193	Potassium oxalate.
Riché, A.	Compt. Rend.	1877	85	226	Ammonium sulphate and hydrate and acetic acid.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Ammonium sulphate and sulphuric acid.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	198	Sodium acetate and acetic acid.
Smith, E. F., and Muhr, F.	J. Analyt. & App. Chem.	1891	5	488	Tartaric acid and ammonium hydrate.
Thomälen, H.	Zeits. Electrochem.	1894	1	304	Sodium acetate and acetic acid. Potassium oxalate and sulphate.
Vortmann, G.	Ber.	1891	24	2749	Ammonium oxalate; *as amalgam.* Tartaric acid and ammonium hydrate; *as amalgam.*
Vortmann, G.	Monatsh. Chem.	1893	14	536	Potassium tartrate and sodium hydrate.
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Formate and formic acid.
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Ammonium hydrate.

IV. *Quantitative Methods for the Separation of Metals by means of Electrolysis.*

The methods of separation are arranged under the heads of the following metals :—

1. Antimony.	4. Chromium.	7. Gold.	10. Nickel.	13. Silver.
2. Bismuth.	5. Cobalt.	8. Iron.	11. Palladium.	14. Zinc.
3. Cadmium.	6. Copper.	9. Mercury.	12. Platinum.	

The separations are arranged under the head of that metal which is determined electrolytically. When two or more metals are determined electrolytically the reference is given in the relative alphabetical order of the metals,

Author	Journal	Year	Vol.	Page	Metals separated from	Composition of Electrolyte
		1. Antimony.				
Classen, A., and Ludwig, R.	Ber.	1885	18	1104	As, Sn	Sodium sulphide and hydrate.
Classen, A., and Ludwig, R.	Ber.	1886	19	323	As, Sn	Sodium sulphide and hydrate.
Classen, A., and Schelle, R.	Ber.	1888	21	2892	Sn	Sodium sulphide and hydrate.
Classen, A.	Ber.	1894	27	2060	As, Sn	Sodium sulphide and hydrate.
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	As, Sn	Sodium sulphide and hydrate.
		2. Bismuth.				
Classen, A.	Ber.	1881	14	2771	Mn	Ammonium and potassium oxalates.
Classen, A., and Ludwig, R.	Ber.	1886	19	323	Co, Ni, U, Zn	Ammonium and potassium oxalates.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Cu	Potassium cyanide and citric acid.
Schmucker, S. C.	J. Amer. Chem. Soc.	1893	15	195	Sb, As, Sn	Ammonium hydrate and tartaric acid.
Smith, E. F., & Knerr, E. B.	Amer. Chem. J.	1885	8	206	Cd, Co, Fe, Mn, Ni, U, Zn	Sulphuric acid.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	428	Cu	Potassium cyanide and citric acid.
Smith, E. F., & Saltar, J. C.	J. Analyt. & App. Chem.	1893	7	128	Pb	Nitric acid.
Smith, E. F., & Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	252	Cd, Co, Pb, Hg, Ni, Zn	Nitric acid.
Smith, E. F.	Zeits. anorg. Chem.	1894	6	43	Pb	Nitric acid.

3. Cadmium.

Brand, A.	Zeits. anal. Chem.	1889	28	581	Co, Fe, Ni, Zn Mn	Sulphuric acid. Sodium pyrophosphate and sulphuric acid or ammonium hydrate.
Classen, A.	Ber.	1881	14	2771	Mn	Ammonium and potassium oxalates.
Eliasberg, S.	Zeits. anal. Chem.	1885	24	548	Zn	Sodium acetate and acetic acid. Ammonium and potassium oxalates.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	As, Co, Cu, Zn Co, Fe, Zn	Potassium cyanide. Ammonium sulphate and sulphuric acid.
Moore, T.	Chem. News	1886	53	209	Zn	Phosphoric acid.
Schmucker, S. C.	J. Amer. Chem. Soc.	1893	15	195	Sb, As, Sn	Ammonium hydrate and tartaric acid.
Smith, E. F., & Knerr, E. B.	Amer. Chem. J.	1885	8	206	Zn	Acetates and acetic acid. Tartrates and tartaric acid.
Smith, E. F.	J. Analyt. & App. Chem.	1889	3	385	Cu	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1889	11	352	Zn	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	104	Co, Ni	Potassium cyanide.
Smith, E. F.	Amer. Chem. J.	1890	12	329	Al, Cr, Fe, Ni, Zn	Sodium phosphate and phosphoric acid.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	428	As, Mo, W	Potassium cyanide.
Smith, E. F.	Amer. Chem. J.	1891	13	206	Mn	Sodium phosphate and phosphoric acid.
Smith, E. F., & Wallace, D. L.	Ber.	1892	25	779	Os	Potassium cyanide.
Warwick, H. S.	Zeits. anorg. Chem. Chem. News	1892 1892	1 66	285 255	Co, Fe, Mn, Ni, Zn	Formates and formic acid.
Yver, A.	Bull. Soc. Chim.	1880	34	18	Zn	Sodium acetate and acetic acid.

4. Chromium.

Classen, A.	Ber.	1884	17	2467	U	Ammonium oxalate.

IV. *Quantitative Methods for the Separation of Metals by means of Electrolysis*—continued.

Author	Journal	Year	Vol.	Page	Metals separated from	Composition of Electrolyte
5. Cobalt.						
Brand, A.	Zeits. anal. Chem.	1889	28	581	Al, Mg, U.	Sodium pyrophosphate.
					Mn	Sodium pyrophosphate and ammonium oxalate.
Classen, A.	Ber.	1881	14	2771	Mn	Ammonium and potassium oxalates.
Classen, A.	Ber.	1884	17	2467	Cr, Mn	Ammonium oxalate.
					Fe	Ammonium and potassium oxalates.
Classen, A.	Ber.	1894	27	2060	Fe	Ammonium oxalate.
Le Roy, G. A.	Compt. Rend.	1891	112	722	Fe, Mn	Citric acid, ammonium sulphate, and hydrate.
Moore, T.	Chem. News	1886	53	209	Al, Cr, Mn.	Phosphoric acid and ammonium carbonate.
Vortmann, G.	Monats. Chem.	1893	14	536	Fe	Ammonium sulphate and hydrate.
					Ni	Alkali tartrate and potassium iodide.
6. Copper.						
Boisbaudron, Lecoq de	Zeits. anal. Chem.	1870	9	102	Fe	Sulphuric acid.
Brand, A.	Zeits. anal. Chem.	1889	28	581	Mn	Sodium pyrophosphate and ammonium hydrate, or sulphuric acid, or nitric acid.
Classen, A.	Ber.	1881	14	2771	Mn	Potassium and ammonium oxalates.
Classen, A.	Ber.	1884	17	2467	Al, Co, Cr, Fe, Mg, Mn, Ni, Zn, Phosphoric acid	Ammonium oxalate.
					Zn	Sulphuric acid.
					Cd	Nitric acid.

Classen, A.	Ber.	1888	21	359	As, Pb	Nitric acid.
Classen, A.	Zeits. anorg. Chem.	1893	4	234	Bi	Nitric acid.
Classen, A.	Zeits. anorg. Chem.	1893	5	299	Bi	Nitric acid.
Classen, A.	Ber.	1894	27	163	Pb	Nitric acid.
Classen, A.	Ber.	1894	27	2060	Co, Fe, Ni	Ammonium oxalate and oxalic, tartaric, or acetic acid.
					Fe, Pb	Nitric acid.
Croasdale, S.	J. Analyt. & App. Chem.	1891	5	133, 184	Al, Sb, As, Ba, Bi, Cd, Ca, Cr, Co, Au, Fe, Pb, Mg, Mn, Hg, Ni, K, Ag, Na, Sn, Zn	Nitric acid or Sulphuric acid.
Drossbach, G P.	Chem.-Zeit.	1892	16	818	As, Sb, Bi, Cr, Co, Fe, Pb, Mn, Ni, Ag, Sn, Zn	Ammonium hydrate.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Sb, As, Cd	Sulphuric acid or nitric acid.
					As	Potassium cyanide.
					Bi	Potassium cyanide and citric acid.
					Sb, As	Ammonium hydrate.
Hampe, W.	Zeits. anal. Chem.	1874	13	176	Bi, Pb	Nitric acid.
Hampe, W.	Chem.-Zeit.	1892	16	417	Sb	Nitric acid.
Herpin	Zeits. anal. Chem.	1876	15	335	Ni	Sulphuric acid.
Kiliani, M.	Berg- u. hütten. Zeit.	1884	43	375, 399, 423	Ag	Nitric acid.
Luckow, C.	Dingler Polyt. J.	1864	177	296	Co, Fe, Mn, Ni, Zn	Sulphuric acid.
Luckow, C.	Zeits. anal. Chem.	1869	8	23	Sb, As, Ba, Ca, Co, Cr, Fe, Pb, Mg, Mn, Ni, K, Na, Ag, Zn	Nitric acid.
McKay, L. W.	Chem.-Zeit.	1890	14	509	As	Ammonium hydrate.
Mansfeld Direction	Zeits. anal. Chem.	1872	11	1	Sb, As, Pb, Se	Nitric acid.
May, W. C.	Zeits. anal. Chem.	1875	14	347	Pb	Nitric acid.
Merrick, J. M.	Amer. Chem. J.	1871	2	136	Ni	Sulphuric acid.
Nüssenson, H.	Zeits. angew. Chem.	1893	—	646	Pb	Nitric acid.
Oettel, F.	Zeits. anal. Chem.	1888	27	15	Pb	Nitric acid.
Oeschger and Mesdach	Bull. Soc. Chim.	1875	23	180	Co, Ni	Nitric acid.
Richè, A.	Compt. Rend.	1877	85	226	Pb	Nitric acid.

IV. *Quantitative Methods for the Separation of Metals by means of Electrolysis*—continued.

Author	Journal	Year	Vol.	Page	Metals separated from	Composition of Electrolyte
					COPPER—*continued.*	
Riché, A.	Annales Chim. et Phys.	1882	13	508	Al, Cd, Fe, Pb, Mn, Ni, U, Zn, alkaline earths and alkalis, acetic, tartaric, and phosphoric acids	Sulphuric acid.
Rüdorff, F.	Zeits. angew. Chem.	1892	—	695	Cd, Hg, Ni, Ag	Potassium cyanide.
					Cd	Nitric acid.
Rüdorff, F.	Zeits. angew. Chem.	1893	—	450	Cu	Potassium and ammonium oxalates.
					Cu, Fe, Zn	Sulphuric acid.
					Pb	Nitric acid and sodium nitrate.
					Mn	Nitric acid.
Schweder, P.	Zeits. anal. Chem.	1877	16	344	Ni	Nitric acid.
Schmucker, S. C.	J. Amer. Chem. Soc.	1893	15	195	Sb, As, Sn	Ammonium hydrate and tartaric acid.
Smith, E. F.	Amer. Chem. J.	1880	2	41	Cd	Nitric acid.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	104	Cd	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	428	As	Potassium cyanide. Ammonium hydrate.
Smith, E. F.	Amer. Chem. J.	1890	12	329	Cd, Co, Cr, Fe, Mn, Ni, Zn	Sodium phosphate and phosphoric acid.
Smith, E. F., & Saltar, J. C.	J. Analyt. & App. Chem.	1893	7	128	Bi, Pb	Nitric acid.
Smith, E. F., & Wallace, D. L.	J. Analyt. & App. Chem.	1893	7	189	Sb	Ammonium hydrate and tartaric acid.
Smith, E. F., & Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	252	Cd, Co, Fe, Ni, Zn	Nitric acid.
Smith, E. F.	Zeits. anorg. Chem.	1893	5	197	Bi	Nitric acid.
Smith, E. F., & Spencer, H. E.	J. Amer. Chem. Soc.	1894	16	420	Hg, Ag	Potassium cyanide.
Stahl, W.	Dingler Polyt. J.	1886	262	277	Bi	Nitric acid.
Tenney, F.	Amer. Chem. J.	1883	5	413	Pb	Nitric acid.
Vortmann, G.	Monats. Chem.	1893	14	536	Fe	Ammonium sulphate and hydrate.
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Co, Fe, Ni, Zn	Formates and formic acid.
Wrightson, F.	Zeits. anal. Chem.	1876	15	297	Sb, Ni	Nitric acid.

7. Gold.

Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	As, Cu, Pt	Potassium cyanide.
Smith, E. F.	Amer. Chem. J.	1891	13	206	Co, Zn	Sodium phosphate and phosphoric acid.
Smith, E. F., & Muhr, F.	Amer. Chem. J.	1891	13	417	Co, Cu, Ni, Pd, Pt, Zn	Potassium cyanide.
Smith, E. F.	J. Analyt. & App. Chem.	1891	5	204	As, Mo, Sn, W, V	Sodium sulphide and hydrate.
Smith, E. F., & Wallace, D. L.	Ber.	1892	25	779	As, Mo, Os, W	Potassium cyanide.

8. Iron.

Brand, A.	Zeits. phys. Chem.	1889	28	581	{ Al, Mg, U { Mn	Sodium pyrophosphate. Sodium pyrophosphate and ammonium oxalate.
Classen, A., and Reis, M. A.	Ber.	1881	14	1622	Al, Mn	Ammonium oxalate.
Classen, A.	Ber.	1881	14	2771	{ Al, Be, Cr, V, Zr { Mn, Sulphuric acid, Phosphoric acid	Ammonium oxalate. Ammonium and potassium oxalates.
Classen, A.	Ber.	1884	17	2351	{ Al { Mn	Ammonium oxalate. Ammonium and potassium oxalates.
Classen, A.	Ber.	1884	17	2467	Co, Ni, U, Zn	Ammonium and potassium oxalates.
Classen, A.	Ber.	1885	18	168	{ Al { Mn	Ammonium oxalate. Ammonium and potassium oxalates.
Classen, A.	Ber.	1885	18	1789	Al, Mn	Ammonium oxalate.
Classen, A.	Ber.	1894	27	2060	{ Co, Ni { Al, Cr	Ammonium oxalate. Ammonium and potassium oxalates.
Gibbs, W.	Amer. Chem. J.	1891	13	570	Al	Sulphates; *as amalgam.*
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Al, Cr, Mn, Zn	Ammonium and potassium oxalates.
Moore, T.	Chem. News	1886	53	209	Al, Cr, Mn	Phosphoric acid and ammonium carbonate.
Smith, E. F.	Amer. Chem. J.	1888	10	330	Al	Sodium citrate.
Smith, E. F., and Muhr, F.	J. Analyt. and App. Chem.	1891	5	488	Al	Tartaric acid and ammonium hydrate.

IV. *Quantitative Methods for the Separation of Metals by means of Electrolysis*—continued.

Author	Journal	Year	Vol.	Page	Metals separated from	Composition of Electrolyte
		IRON—*continued.*				
Vortmann, G.	Monats. Chem.	1893	14	536	Ni	Alkali tartrate and potassium iodide.
Wieland, J.	Ber.	1884	17	1611	Al	Ammonium oxalate.
				2931	Mn	Ammonium and potassium oxalates.
		9. MERCURY.				
Brand, A.	Zeits. anal. Chem.	1889	28	581	Mn	Sodium pyrophosphate and ammonium hydrate or sulphuric or nitric acid.
Classen, A., and Ludwig, R.	Ber.	1886	19	323	Al, Ba, Ca, Cd, Co, Cr, Fe, Mg, Mn, Ni, Sr, U	Nitric acid.
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Cd, Cu	Potassium cyanide.
					As, Bi, Cu	Nitric acid.
					Sb, As	Ammonium hydrate and tartaric acid.
Rüdorff, F.	Zeits. angew. Chem.	1894	—	388	Fe, Mn, Ni, Zn	Sulphuric acid.
					Cd	Nitric acid.
					Ni	Sodium sulphate and ammonium hydrate.
Schmucker, S. C.	J. Amer. Chem. Soc.	1893	15	193	As, Sb, Sn	Ammonium hydrate and tartaric acid.
Smith, E. F., & Frankel, L. K.	J. Analyt. & App. Chem.	1889	3	254	Cu	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1889	11	264	Cu, Ag	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	104	Co, Ni, Zn	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	428	As, Mo, Pd, W	Potassium cyanide.
Smith, E. F.	J. Analyt. & App. Chem.	1891	5	202	As, Sn	Sodium sulphide.
Smith, E. F., and McCauley, W. A.	J. Analyt. & App. Chem.	1891	5	489	Cu, Ni, Zn	Potassium cyanide.
	Ber.	1891	24	2936		

Smith, E. F., and Muhr, F.	Amer. Chem. J.	1891	13	417	Pt	Potassium cyanide.
	Ber.	1891	24	2175		
Smith, E. F., and Wallace, D. L.	Ber.	1892	25	779	Os	Potassium cyanide.
Smith, E. F., & Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	185	Bi	Nitric acid.
Smith, E. F., & Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	252	Bi, Pb	Nitric acid.

10. Nickel.

Brand, A.	Zeits. anal. Chem.	1889	28	581	Al, Mg, U	Sodium pyrophosphate.
					Mn	Sodium pyrophosphate and ammonium hydrate.
Cheney, M. S., and Richards, E. S.	Zeits. anal. Chem.	1878	17	215	Fe	Ammonium sulphate and hydrate (after precipitation as phosphate).
Classen, A.	Ber.	1881	14	2771	Mn	Ammonium and potassium oxalates.
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Mn	Ammonium oxalate.
Langbein	Zeits. anal. Chem.	1887	26	732	Mn	Ammonium hydrate and chloride.
Le Roy, G. A.	Compt. Rend.	1891	112	722	Fe, Mn	Ammonium sulphate and hydrate.
Moore, T.	Chem. News	1886	53	209	Al, Cr, Mn	Phosphoric acid and ammonium carbonate.
Riché, A.	Compt. Rend.	1877	85	226	Mg	Ammonium hydrate.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Mg, Mn	Sulphuric acid.
Scheweder, P.	Zeits. anal. Chem.	1877	16	344	Fe	Ammonium sulphate and hydrate.
Vortmann, G.	Monats. Chem.	1893	14	536	Al	Ammonium sulphate and hydrate.
					Zn	Alkali tartrate and potassium iodide.

11. Palladium.

Smith, E. F.	Amer. Chem. J.	1892	14	435	Ir	Sodium phosphate and phosphoric acid.

12. Platinum.

Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	Au, Hg, Ag	Potassium cyanide.
					As, Sn	Hydrochloric acid.
Smith, E. F.	Amer. Chem. J.	1892	14	435	Ir	Sodium phosphate and phosphoric acid.

IV. *Quantitative Methods for the Separation of Metals by means of Electrolysis*—continued.

Author	Journal	Year	Vol.	Page	Metals separated from	Composition of Electrolyte
13. Silver.						
Freudenberg, H.	Zeits. phys. Chem.	1893	12	97	As, Cd, Co, Cu, Ni, Pt, Zn	Potassium cyanide.
					As, Cd	Ammonium sulphate and hydrate.
					Sb	Nitric and tartaric acids. / Potassium cyanide and tartaric acid.
					Bi	Nitric acid and ammonium nitrate.
Luckow, C.	Zeits. angew. Chem.	1890	—	345	Pb	Nitric and oxalic acids.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Pb	Nitric acid.
					Zn	Ammonium sulphate and sulphuric acid.
Smith, E. F., & Frankel, L. K.	J. Analyt. & App. Chem.	1889	3	254	Cu	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	104	Cu, Ni, Zn	Potassium cyanide.
Smith, E. F., & Frankel, L. K.	Amer. Chem. J.	1890	12	428	As, Mo, W	Potassium cyanide.
Smith, E. F., & Muhr, F.	Amer. Chem. J.	1891	13	417	Pt	Potassium cyanide.
Smith, E. F., & Wallace, D. L.	Ber.	1892	25	779	Os	Potassium cyanide.
Smith, E. F., & Moyer, J. B.	J. Analyt. & App. Chem.	1893	7	252	Pb	Nitric acid.
Smith, E. F., & Spencer, H. E.	J. Amer. Chem. Soc.	1894	16	420	Cd	Potassium cyanide.
14. Zinc.						
Brand, A.	Zeits. anal. Chem.	1889	28	581	Al, Mg, U	Sodium pyrophosphate.
					Mn	Sodium pyrophosphate and ammonium hydrate.
Classen, A.	Ber.	1881	14	2771	Mn	Ammonium and potassium oxalates.
Classen, A.	Ber.	1884	17	2467	Cr, U	Ammonium oxalate.
Kohn, C. A., & Woodgate, J.	J. Soc. Chem. Ind.	1889	8	256	Mn	Ammonium sulphate and hydrate.
Luckow, C.	Chem.-Zeit.	1885	9	338	Co, Fe, Mn, Ni, Pt	Hydrochloric or sulphuric acid; *as amalgam*.
Moore, T.	Chem. News	1886	53	209	Al, Cr, Mn	Phosphoric acid and ammonium carbonate.
Riché, A.	Annales Chim. et Phys.	1882	13	508	Pb, Mg, Mn, K, Na	Nitric acid. / Sulphuric acid.

Vortmann, G.	Monats. Chem.	1893	14	536	Fe	Potassium cyanide and sodium hydrate.
Warwick, H. S.	Zeits. anorg. Chem.	1892	1	285	Co, Fe, Mn, Ni	Formates and formic acid.

V. *Special Applications of Electrolysis in Quantitative Analysis.*

Author	Journal	Year	Volume	Page	Subject
Classen, A.	Ber.	1884	17	2467	Indirect determination of potassium, ammonium, and nitrogen.
Frankel, L. K.	Chem. News	1892	65	55	Oxidation of metallic arsenides by the electric current.
Kinnicutt, L. P.	Amer. Chem. J.	1882	4	22	Indirect determination of chlorine and bromine electrolytically.
Rinman, C	Zeits. anal. Chem.	1864	3	336	Determination of carbon in steel.
Ross, B. B.	J. Analyt. & App. Chem.	1893	7	83	The electrolytic estimation of copper as applied to invert-sugar determinations.
Smith, E. F.	Ber.	1889	22	1019	Oxidation of sulphides by the electric current.
	Ber.	1890	23	2276	
	J. Franklin Inst.	1889	97	313	
Smith, E. F.	Ber.	1891	24	2182	Decomposition of chromite by the electric current.
	Amer. Chem. J.	1891	13	414	
Smith, E. F., and Wallace, D. L.	Ber.	1891	24	2938	Oxidation of chalcocite by the electric current.
	J. Analyt. & App. Chem.	1891	5	490	
Vortmann, G.	Ber.	1890	23	2798	The determination of nitric acid by electrolysis.
Vortmann, G.	Monats. Chem.	1894	15	280	Electrolytic determination of halogens.
Weyl, W.	Zeits. anal. Chem.	1862	1	112	Determination of carbon in iron.
Whitfield, J. E.	Amer. Chem. J.	1886	8	421	Indirect determination of chlorine, bromine, and iodine by the electrolysis of their silver salts.

Atomic-weight Determinations by means of Electrolysis.

Author	Journal	Year	Volume	Page	Subject
Hampe, W.	Zeits. anal. Chem.	1874	13	352	Copper.
Bongartz, J., & Classen, A.	Ber.	1888	21	2900	Tin.
Classen, A.	Ber.	1890	23	938	Bismuth.
Keller, H. F., & Smith, E. F.	Amer. Chem. J.	1892	14	423	Palladium.
Lorimer, W. S., & Smith, E. F.	Zeits. anorg. Chem.	1892	1	364	Cadmium.

VI. *Applications of Electrolysis to Qualitative Analysis (including sundry Papers bearing on Electrolytic Analysis).*

Author	Journal	Year	Volume	Page	Subject
Becquerel, E.	Annales Chim. et Phys.	1830	43	380	Detection of lead and manganese in presence of iron and other metals.
Bloxam, C.	J. Chem. Soc.	1861	13	12	Detection of poisonous metals in mixtures containing organic matters (Sb, As, Bi, Cu, Hg).
Bloxam, C.	J. Chem. Soc.	1861	13	338	Electrolytic test for arsenic.
Chittenden	Proc. Connecticut Acad. Science.	—	8	—	Detection of antimony in organic matter and in urine.
	Classen's Quantitative Analysis by Electrolysis, trans. by Herrick	1887	—	5	
De Claubry	Jahresber. Chem.	1850	3	602	Detection of metallic poisons (copper, zinc).
Donny and Lynch	Zeits. anal. Chem.	1870	9	105	Detection of arsenic.
Frankel, L. K.	J. Franklin Inst.	1891	101	141	Electrolysis of metallic thiocyanates.
	Chem. News	1891	63	198	
Guyard, A.	Compt. Rend	1883	97	673	Detection of manganese in zinc and zinc ores. Detection of bismuth in lead.
Kohn, C. A.	J. Soc. Chem. Ind.	1891	10	327	Detection of metallic poisons and of antimony, copper, lead, and mercury in urine.
Krüss, G.	Zeits. anorg. Chem.	1892	2	60	Electrolysis of salts of the rare earths.
Lazarevic	Zeits. anal. Chem.	1880	19	250	Detection of mercury.
Luckow, C.	Dingler Polyt. J.	1864	177	231	Detection of lead and manganese.
Luckow, C.	Zeits. anal. Chem.	1880	19	1	Electrolysis of salts of chromium, alkali sulphides, potassium cyanide, nitric, sulphuric, and sulphurous acids.
Mayençon	J. Soc. Chem. Ind.	1887	6	836	Detection of gold.
Nicklés, J.	Zeits. anal. Chem.	1863	2	114	Detection of silver.
Schucht, L.	Zeits. anal. Chem.	1883	22	485	Conditions under which oxides formed during electrolysis from solutions of Bi, Co, Pb, Mn, Ni, Se, Ag, Te, Th.
Smith, E. F.	Ber.	1880	13	751	Electrolysis of salts of cerium, didymium, tungsten, and vanadium.
Wolff, C. H.	Rep. anal. Chem.	1883	3	114	Detection of mercury.
Wolff, C. H.	Pharm. Central Halle	1886	7	608	Detection of arsenic.
Wolff, C. H.	Zeits. angew. Chem.	1888	—	294	Detection of mercury.
Wolff, C. H.	Pharm. Central Halle	1891	22	493	Detection of arsenic.

The Bibliography of Spectroscopy.—Report of the Committee, consisting of Professor H. McLeod, Professor W. C. Roberts Austen, Mr. H. G. Madan, *and* Mr. D. H. Nagel.

Progress has been made with the catalogue of spectroscopic literature, which has now been brought nearly up to date; but, in view of the difficulty of obtaining assistance from any one who is within reach of the great scientific libraries, the Committee do not see their way to its further continuance.

They therefore propose to bring the catalogue to a conclusion at the end of the present year, so as to form a twenty-five-years' record of spectroscopic literature.

Four instalments of the list of papers have been already issued, and will be found in the reports of the Association for 1881, 1884, 1889, and 1894. The inconvenience of having to refer to four distinct volumes in order to obtain a complete list of papers on any particular subject is obvious, and the Committee strongly recommend that all the separate instalments should be collected, rearranged, and issued as one continuous catalogue. Mr. Madan is quite willing to undertake gratuitously all the labour of doing this, the only question is that of expense of printing.

In an estimate obtained last year, Messrs. Spottiswoode & Co. stated that the cost of printing 500 copies of the first three instalments (1881, 1884, and 1889) would be about 95*l.* The cost, therefore, of printing the whole catalogue would be about 130*l.*

If the above recommendation is approved by the Association, the Committee would suggest that the Association might undertake the responsibility of the cost of printing, and be recouped (in part at least) by the charge of 2*s.* 6*d.* per copy (which would produce 62*l.* 10*s.*). Or a higher charge might be made.

It appears, moreover, not unlikely that other scientific societies—the Royal Society, the Chemical Society, and the Physical Society—might be induced to make grants, if, as is hoped, the catalogue would be of value to those who are engaged in physical research.

The Committee desire to present the above subject for discussion, and ask to be reappointed for one more year in order to finish their work.

The Action of Light upon Dyed Colours.—Report of the Committee, consisting of Dr. T. E. Thorpe (*Chairman*), Professor J. J. Hummel (*Secretary*), Dr. W. H. Perkin, Professor W. J. Russell, Captain W. de W. Abney, Professor W. Stroud, *and* Professor R. Meldola. (*Drawn up by the Secretary.*)

During the past year (1894–95) the work of this Committee has been continued, and a large number of wool and silk patterns, dyed with various natural and artificial *red*, *orange*, and *yellow* colouring matters, have been examined with respect to their power of resisting the fading action of light.

Similar patterns were exposed to light in the years 1892–93 and 1893–94, and have already been reported upon, but for want of sufficient exposing space certain important groups of colouring matters had to remain unrepresented, *e.g.*, the Congo Reds, &c. These have now been examined, together with additional coal-tar colouring matters recently introduced, also certain Indian dyestuffs. With some few exceptions, therefore, all the available red, orange, and yellow colours, as applied to wool and silk, have now been exposed.

The general method of preparing the dyed patterns, and the manner of exposing them under glass, with free access of air and moisture, were the same as already adopted.

The thanks of the Committee are again due to James A. Hirst, Esq., in whose grounds the patterns were exposed at Adel, near Leeds.

Each dyed pattern was divided into six pieces, one of which was protected from the action of light, while the others were exposed for different periods of time. These 'periods of exposure' were made equivalent to those adopted in previous years by exposing, along with the patterns, special series of 'standards,' dyed with the same colouring matters as were then selected for this purpose. The standards were allowed to fade to the same extent as those which marked off the 'fading period' in previous years, before being renewed or removing a set of dyed patterns from the action of light. The patterns exposed during the past year are therefore comparable, in respect of the amount of fading which they have experienced, with the dyes already reported upon.

The patterns were all put out for exposure on June 20, 1894, certain sets being subsequently removed on the following dates:—July 14, August 20, September 22, 1894; April 13, July 16, 1895. Of these five 'periods of exposure' thus marked off, periods 1, 2, 3 were equivalent to each other in fading power, whereas periods 4 and 5 were each equivalent to *four* of the first period in this respect; hence five patterns of each colour have been submitted respectively to an amount of fading equal to 1, 2, 3, 7, and 11 times that of the first 'fading period' selected—viz. June 20 to July 14, 1894.

The dyed and faded patterns have again been entered in pattern-card books in such a manner that they can be readily compared with each other.

The following tables give the general result of the exposure experiments made during the year 1894–95, the colours being divided, according to their behaviour towards light, into the following five classes: very fugitive, fugitive, moderately fast, fast, very fast.

The initial numbers refer to the order of the patterns in the pattern-books. The S. and J. numbers refer to Schultz and Julius's 'Tabellarische Uebersicht der künstlichen organischen Farbstoffen.'

In the case of colouring matters requiring mordants, the particular mordant employed is indicated in brackets after the name of the dyestuff.

RED COLOURING MATTERS.

Class I. Very Fugitive Colours. (Wool.)

The colours of this class have faded so rapidly that at the end of the first 'fading period' (June 20 to July 14, 1894) only a very faint colour remains, and at the end of the fifth period (one year) all traces of the original colour have disappeared, the woollen cloth being either quite white or merely of a faint tint which varies according to the colour of the original pattern.

Triphenylmethan Colour.

Wool Book V.
Acid Colour. 20. Bengaline PH extra. Constitution not published.

Azo Colours.

Direct Cotton Colours. 4. Rosazurin B. From *o*-tolidine and methyl-β-naphthylamine-sulphonic acid δ. S. and J. 199.
" 14. Naphthylene Red. From 1.5-diamido-naphthalene and naphthionic acid. S. and J. 147.
" 15. Rosazurin G. From *o*-tolidine, methyl-β-naphthylamine-sulphonic acid δ, and β-naphthylamine-sulphonic acid δ. S. and J. 198.
" 46. Terra Cotta F. From primuline and *p*-sulpho-naphthalene-azo-*m*-phenylene-diamine.
Developed Colour. 1. Primuline Red. From primuline and β-naphthol.

Natural Colouring Matters.

Wool Book VI.
Non-mordant Colour. 1. Orchil. From Roccella tinctoria
Mordant Colours. 7. Barwood (Al.). Wood of Baphia nitida.
" 8. Sanderswood (Al.). Wood of Pterocarpus santalinus.

Notes.—Rosazurin B and G become yellower during the fading process, a change which is still more pronounced in the case of Naphthylene Red. The Barwood and Sanderswood reds become brown during the first fading period, and then rapidly fade to a pale drab, and finally, at the end of a year, to a buff colour.

Class II. Fugitive Colours. (Wool.)

The colours of this class show very marked fading at the end of the second 'fading period' (July 14 to August 20, 1894), and after a year's exposure they have entirely faded, or only a tint remains.

Azo Colours.

Wool Book V.
Acid Colours. 1. Azo Orchil R. Constitution not published.
" 4. Fast Acid Magenta. Constitution not published.
" 13. Emin Red. Constitution not published.
" 14. Azo Cardinal G. Constitution not published.
Direct Cotton Colours. 1. Brilliant Geranine B. Constitution not published.
2. Brilliant Geranine 3B. Constitution not published.
" 3. Congo Rubin. Constitution not published.
" 5. Titan Red. Constitution not published.
" 9. Benzopurpurin 10B. From dianisidine and naphthionic acid, S. and J. 214.
" 11. Hessian Purple N. From diamido-stilbene-disulphonic acid and β-naphthylamine. S. and J. 150.
" 13. Diamine Red NO. From ethoxy-benzidine, β-naphthylamine-β-sulphonic acid and β-naphthylamine-δ-sulphonic acid. S. and J. 203.
" 18. Hessian Purple B. From diamido-stilbene-disulphonic acid and β-naphthylamine-sulphonic acid (β and δ). S. and J. 152.
" 19. Hessian Brilliant Purple. From diamido-stilbene-disulphonic acid and β-naphthylamine-β-sulphonic acid. S. and J. 151.
" 20. Hessian Purple D. From diamido-stilbene-disulphonic acid and β-naphthylamine-mono-sulphonic acid γ. S. and J. 153.
" 21. Benzo Fast Red. Constitution not published.
" 22. Titan Scarlet C. Constitution not published.
" 24. Benzopurpurin 6B. From tolidine and α-naphthylamine-mono-sulphonic acid L. S. and J. 190.

Direct Cotton Colours. 26. Deltapurpurin 5B. From tolidine, β-naphthylamine-δ-sulphonic acid, and β-naphthylamine-sulphonic acid (β and δ). S. and J. 192.

„ 27. Deltapurpurin 7B. From tolidine and β-naphthylamine-δ-sulphonic acid. S. and J. 200.

„ 28. Congo Red. From benzidine and naphthionic acid. S. and J. 163.

„ 31. Benzopurpurin 4B. From tolidine and naphthionic acid. S. and J. 189.

„ 33. Benzopurpurin B. From tolidine and β-naphthylamine-monosulphonic acid Br. S. and J. 191.

„ 34. Direct Red. From diamido-ethoxy-tolyl-phenyl and naphthionic acid.

„ 38. Congo GR. Constitution not published.

„ 42. Deltapurpurin G. From benzidine and β-naphthylamine-monosulphonic acid (β and δ). S. and J. 164.

„ 44. Congo 4R. From *o*-tolidine, naphthionic acid and resorcinol.

„ 45. Direct Red. From diamido-phenyl-tolyl and naphthionic acid. S. and J. 184.

Natural Colouring Matters.

Wool Book VI.

Mordant Colours. 1. Ventilago madraspatana (root-bark) (Al.) (Sn.).

„ 2. Limawood (Al.) (Sn.). Wood of Caesalpinia echinata.

„ 6. Camwood (Al.) (Sn.).

„ 7. Barwood (Sn.).

„ 8. Sanderswood (Sn.).

Notes.—Fast Acid Magenta becomes much bluer during the first fading period, and assumes quite a purple colour, which gradually fades to a purplish grey. Its behaviour is quite unlike that of ordinary Acid Magenta, but very similar to that of Magenta itself, from which it is no doubt derived.

Emin Red is one of the more fugitive colours of this class, and might almost be placed in Class I.

Iso-Rubin R behaves like ordinary Magenta, and changes during the first fading period to a purple, which soon fades still further.

The colours given by *Ventilago madraspatana*, Limawood and Camwood, with tin mordant, are all a little faster than with aluminium. The Camwood, Barwood and Sanderswood colours with aluminium and tin mordants all become brown and apparently darker during the first fading period; those obtained with tin mordant become much darker, and are somewhat faster than the corresponding aluminium colours. This marked alteration in hue during the early stages of the fading process is characteristic of these dyestuffs, and distinguishes them readily from *Ventilago madraspatana* and Limawood.

Class III. Moderately Fast Colours. (Wool.)

The colours of this class show distinct fading at the end of the second period (July 14 to August 20, 1894), which becomes more pronounced at the end of the third period (August 20 to September 22, 1894). A pale tint only remains at the end of the fourth period (September 22, 1894, to April 13, 1895), and at the end of a year's exposure the colour has entirely faded, or, at most, mere traces of colour remain.

Azo Colours.

Wool Book V.

Acid Colours. 6. Azo Carmine BX. Sodium salt of phenyl-rosinduline-tri-sulphonic acid.

„ 8. Croceïn Scarlet 10B. Constitution not published.

Acid Colours. 9. Ponceau 10RB. Constitution not published.
„ 10. Fast Wool Red. From naphthionic acid and β-naphthol-disulphonic acid.
„ 11. Azo Bordeaux. Constitution not published.
„ 15. Anthracene Red. Constitution not published.
„ 16. Azo Cochineal. Constitution not published.
„ 19. Milling Scarlet. From di-*m*-amido-azoxytoluene, α-naphthol-mono-sulphonic acid, and β-naphthol-disulphonic acid R.
Direct Cotton Colours. 6. Erica B. From dehydro-thio-*m*-xylidine and α-naphthol-ε-disulphonic acid. S. and J. 69.
„ 7. Geranine BB. Constitution not published.
„ 8. Erica G. Constitution not published.
„ 17. Geranine G. Constitution not published.
„ 23. Brilliant Congo R. From tolidine, β-naphthylamine-mono-sulphonic acid Br, and β-naphthylamine-disulphonic acid R. S. and J. 193.
„ 25. Brilliant Purpurin R. From *o*-tolidine, β-naphthylamine-disulphonic acid R and naphthionic acid. S. and J. 201.
„ 36. St. Denis Red. From diamido-azoxy-toluene and α-naphthol-mono-sulphonic acid NW.
„ 39. Dianthine 4B. Constitution not published.
„ 40. Diamine Scarlet B. From benzidine, β-naphthol-disulphonic acid G, and phenol (ethylated). S. and J. 169.
„ 43. Brilliant Congo G. From benzidine, β-naphthylamine-mono-sulphonic acid β and β-naphthylamine-disulphonic acid R. S. and J 165.

Oxyketone Colour.

Mordant Colour. 4. Alizarin Maroon (Al.) (Sn.). Amido-alizarin.

Natural Colouring Matter.

Mordant Colour. 4. Cochineal (Al.). The insect Coccus cacti.

NOTE.—The more fugitive character of Alizarin Maroon as compared with Alizarin shows that the introduction of the amido group (NH_2) into the alizarin molecule reduces considerably its power of giving fast colours.

CLASS IV. FAST COLOURS. (WOOL.)

The colours of this class show comparatively little fading during the first, second, and third periods. At the end of the fourth period of exposure a pale shade remains, which at the end of the year's exposure still leaves a pale tint.

Azo Colours.

Wool Book V.
Acid Colours. 3. Azo Acid Magenta B. From toluidine and dioxy-naphthalene-α-mono-sulphonic acid (1 : 8). S. and J. 228.
„ 5. Azo Acid Magenta G. From sulphanilic acid and dioxy-naphthalene-α-mono-sulphonic acid (1 : 8). S. and J. 229.

Triphenylmethan Colour.

Wool Book V.
Acid Colour. 2. Violamine A2R. Sodium salt of di-*o*-tolyl-rhodamine-disulphonic acid.

Oxyketone Colour.

Wool Book VI.
Mordant Colour. 8. Purpurin (Al.) Tri-oxy-anthraquinone (1 : 2 : 4).

Natural Colouring Matters.

Wool Book VI.
Mordant Colours. 3. Lac-dye (Al.). The insect Coccus ilicis.
" 9. Munjeet (Al.). Root of Rubia cordifolia.

Notes.—The fastness of Violamine is worthy of special note, since this dyestuff belongs to the Triphenylmethan colours, a group which usually only furnishes fugitive dyes. Violamine is considerably faster than the closely allied Rhodamine, which has been classed as a 'fugitive' colour (see Report, 1892–93).

Class V. Very Fast Colours. (Wool.)

The colours of this class show a very gradual fading during the different periods, and even after a year's exposure a moderately good colour remains.

Azo Colour.

Wool Book V.
Direct Cotton Colour. 16. Diamine Fast Red F. From benzidine, amido-naphthol-sulphonic acid G and salicylic acid. S. and J. 179.

Oxyketone Colours.

Wool Book VI.
Mordant Colours. 1. Alizarin Bordeaux B (Al.) (Sn.). Tetra-oxy-anthraquinone (1 : 2 : 5 : 8).
" 2. Alizarin Bordeaux G (Al.) (Sn.).
" 3. Alizarin Bordeaux GG (Al.) (Sn.).
" 5. Alizarin (Al.). Di-oxy-anthraquinone (1 : 2).
" 6. Anthrapurpurin (Al.). Tri-oxy-anthraquinone (1 : 2 : 7).
" 7. Flavopurpurin (Al.). Tri-oxy-anthraquinone (1 : 2 : 6).
" Nitro-alizarin (Zn.).

Natural Colouring Matters.

Wool Book VI.
Mordant Colours. 10. Chay-root (Al.). Root of Oldenlandia umbellata.
" 11. Morinda-root (Al.) (Sn.). Root of Morinda citrifolia.
" 12. Mang-kudu (Al.) (Sn.). Root of Morinda umbellata.
" 7. Lac-dye (Sn.).
" 8. Cochineal (Sn.).

Notes.—This class includes several colours of the alizarin group, so well known for their general fastness to light, washing, milling, &c. The superior fastness of the red given by Chay-root, as compared with that obtained from Madder, is no doubt due to the absence of Purpurin in the former.

The colours given by Lac-dye and Cochineal with tin mordant are distinctly faster than those with alumina.

Most noteworthy is the remarkable fastness of Diamine Fast Red, since it belongs to the so-called 'Congo Colours,' a group which, as already stated, usually supplies only such red dyes as possess at most a moderate fastness to light.

ORANGE AND YELLOW COLOURING MATTERS.

Class I. Very Fugitive Colours. (Wool.)

Azo Colour.

Wool Book VIII.
Developed Colour. Primuline Orange. From primuline and resorcinol.

Natural Colouring Matters.

Wool Book VIII.
Non-mordant Colours. 3. Gardenia florida (fruit).
" 4. Coscinium fenestratum (root).
" 5. Evodia meliæfolia (bark).

NOTE.—The fugitive character of the dyes given by *Coscinium fenestratum* and *Evodia meliæfolia*, the colouring principle of which is the base Berberine, is quite in accordance with the similar result obtained with all other 'basic colours.'

CLASS II. FUGITIVE COLOURS. (WOOL.)

Azo Colours.

Wool Book VIII.
Acid Colour. 1. Metanil Orange 1. From *m*-diazo-benzene-sulphonic acid and *α*-naphthol. S. and J. 77.
Basic Colours. 1. Tannin Orange R. From *p*-amido-benzyl-dimethyl-amine and *β*-naphthol.
" 2. New Phosphine G. From *p*-amido-benzyl-dimethyl-amine and resorcinol.

Wool Book VII.
Direct Cotton Colours. 2. Toluylene Brown G.
18. Nitrophenine. From *p*-nitraniline and dehydro-thio-*p*-toluidine.
Mordant Colours. 1. Cloth Brown R (Cr.) (Al.) (Sn.). From benzidine, salicyclic acid, and *β*-naphthol-sulphonic-acid. S. and J. 171.
" 4. Cloth Orange (Cr.) (Al.) (Sn.). From benzidine, salicylic acid, and resorcinol. S. and J. 170.
" 13. Congo Brown R (Cr.) (Al.) (Sn.). From naphthionic acid and Cloth Orange. S. and J. 216.
" 14. Congo Brown G (Cr.) (Al.) (Sn.). From sulphanilic acid and Cloth Orange. S. and J. 217.
" 15. Cloth Brown G (Cr.). From benzidine, salicylic acid, and dioxy-naphthalene (2 : 7). S. and J. 172.

Natural Colouring Matters.

Wool Book VIII.
Mordant Colours. Jack-wood (Al.) (Sn.). Wood of Artocarpus integrifolia.
" Kamála (Al.). Fruit glands of Mallotus philippinensis.

NOTES.—Tannin Orange R deserves special notice since it is superior in fastness to all other basic yellows hitherto examined.

The Indian dyestuff Kamála has been regarded by some as a fast dyestuff, but as applied to wool it cannot be so regarded; applied to silk, however, it is very much faster.

CLASS III. MODERATELY FAST COLOURS. (WOOL.)

Azo Colours.

Wool Book VII.
Direct Cotton Colours. 5. Brilliant Orange G. Constitution not published.
6. Toluylene Orange G (O.) (Cr.) (Al.) (Sn.). From tolidine, *o*-cresotinic acid and *m*-toluylene-diamine-sulphonic acid. S. and J. 196.
" 7. Cotton Orange R. From *m*-sulphanilic acid and Cotton Orange G.
" 8. Cotton Orange G. From primuline and *m*-phenylene-diamine-disulphonic acid.
" 2. Benzo Orange R (Cr.) (Al.) (Sn.). From benzidine, salicylic acid, and naphthionic acid. S. and J. 173.
" Cotton Yellow G (Cr.) (Al.) (Sn.). From *p*-amido-acetanilide and salicylic acid, &c. S. and J. 144.

Wool Book VIII. Primuline Yellow. From primuline and phenol.

Wool Book VII.
Acid Colour. 2. Metanil Orange 2. From *m*-sulphanilic acid and *β*-naphthol. S. and J. 77.

Unclassified.

Wool Book VIII.
Acid Colour. Xanthoproteïc acid. Produced by the action of nitric acid on wool.

Natural Colouring Matters.

Wool Book VIII.
Mordant Colours. Jack-wood (Cr.). Wood of Artocarpus integrifolia.
" Morinda-root (dyed without mordant). Root of Morinda citrifolia.

Notes.—Benzo Orange R becomes yellower during fading; at the end of a year's exposure there remains an olive-yellow of medium intensity. With aluminium and tin mordants the fastness is about the same as with chromium.

Toluylene Orange G and Cotton Yellow G, dyed as acid-colours, were exposed last year and placed in this same class. The fastness of the former is the same with chromium, aluminium, and tin mordants; the fastness of the latter is greatest with chromium.

The comparative fastness of the colour given by Morinda-root without the use of any mordant is somewhat interesting.

The bright orange-yellow colour produced by the action of commercial nitric acid on wool, now known as Xanthoproteïc Acid, was at one time supposed to be identical with Picric Acid. Apart from the very decided difference in shade of the two dyes, these exposure experiments confirm most conclusively the present view that they are distinct colouring matters. Picric Acid yellow rapidly changes from a pure lemon-yellow to orange on exposure to light, whereas the orange-yellow colour due to Xanthoproteïc Acid undergoes no such change; it merely becomes in the early stages of fading a little duller and apparently slightly darker. Its behaviour under the influence of light is very similar to that of such colours as Curcumeïn and Azoflavin (reported upon last year), and may possibly indicate that Xanthoproteïc Acid belongs to the class of Nitro-azo colours; at present its constitution is entirely unknown.

Class IV. Fast Colours. (Wool.)

The colours of this class show comparatively little fading during the first, second, and third periods. At the end of the fourth 'period of exposure' a pale shade remains, which at the end of the year's exposure still leaves a pale tint.

Azoxy Colours.

Wool Book VII.
Direct Cotton Colours. 1. Chloramine Orange. Constitution not published.
" 3. Diamine Orange D. Constitution not published.
" 4. Direct Orange 2R. Sodium salt of azo-stilbene-disulphonic acid.

Azo Colours.

Wool Book VII.
Direct Cotton Colours. 9. Cresotin Yellow R (Cr.). From *o*-tolidine and *o*-cresol-carboxylic acid.
" 10. Diamine Yellow N (Cr.). From ethoxy-benzidine, phenol, and salicylic acid (ethylated). S. and J. 204.

NOTES.—The fastness to light of all the azoxy colours here mentioned is so good that they might be almost equally well placed among the 'very fast' colours.

The Direct Orange 2R here referred to is quite distinct from the colouring matter of the same name mentioned in last year's Report, and there classed as a 'very fugitive' colour.

Cresotin Yellow R and Diamine Yellow N were exposed last year, applied as acid-colours. Here, where they are applied on chromium mordant, they appear to be little or no faster to light; applied on aluminium and tin mordants they are distinctly more fugitive.

CLASS V. VERY FAST. (WOOL.)

The colours of this class show a very gradual fading during the different periods, and even after a year's exposure a moderately good colour remains.

Azoxy Colours.

Wool Book VII.	
Direct Cotton Colours.	10. Mikado Gold Yellow 2G. Constitution not published.
	11. Mikado Yellow. Constitution not published.
,,	13. Direct Yellow G. Sodium salt of di-nitroso-stilbene-disulphonic-acid.
,,	14. Diamine Fast Yellow A. Constitution not published.
,,	15. Mikado Gold Yellow 4G. Constitution not published.
,,	16. Mikado Gold Yellow 6G. Constitution not published.
,,	17. Direct Yellow 3G. Oxidation product of Direct Yellow G.

Azo Colours.

Wool Book VII.	
Direct Cotton Colours.	9. Terra Cotta R. From aniline and salicylic acid (nitrated).
	12. Diamine Gold. From di-amido-naphthalene-disulphonic acid (1 : 5 : 3 : 7) and phenol (ethylated).
,,	5. Hessian Yellow (Cr.). From diamido-stilbene-disulphonic acid and salicylic acid. S. and J. 154.
,,	6. Chrysamine R (Cr.). From *o*-tolidine and salicylic acid. S. and J. 195.
,,	7. Chrysamine G (Cr.). From benzidine and salicylic acid. S. and J. 166.
,,	8. Cresotin Yellow G (Cr.). From benzidine and *o*-cresol-carboxylic acid.
,,	11. Carbazol Yellow (Cr.). From diamido-carbazol and salicylic acid. S. and J. 131.

Oxyketone Colours.

Wool Book VIII.	
Mordant Colours.	1. Purpurin (Al.) (Sn.).
,,	2. Alizarin (Al.) (Sn.).
,,	3. Anthrapurpurin (Sn.).
,,	4. Flavopurpurin (Sn.).
,,	5. Alizarin S (Al.) (Sn.). Sulphonic acid of alizarin.
,,	6. Alizarin SS (Al.) (Sn.). Sulphonic acid of anthrapurpurin.
,,	7. Alizarin SSS (Al.) (Sn.). Sulphonic acid of flavopurpurin.

Natural Colouring Matters.

Mordant Colours.	1. Sophora japonica (Cr.) (Sn.).
,,	3. Munjeet (Sn.).
,,	4. Morinda-root (Sn.).
,,	5. Madder (Sn.).
,	6. Chay-root (Sn.).

NOTES.—The following Azo colours, reported upon last year, were exposed after having been applied as acid-colours: Hessian Yellow, Chrysamine R and G, Cresotin Yellow G, and Carbazol Yellow. Those exposed during the past year, and reported upon now, were applied upon chromium mordant. The results now obtained show that all these colours when dyed on chromium mordant are distinctly faster to light than when dyed as acid-colours. An important additional advantage of the chromium colours is that even after a year's exposure the faded colours appear level, showing none of the speckled appearance so frequently noticed with the faded colours dyed by the acid method. When these colours are applied on aluminium and tin mordants they are more fugitive, and may then be classed as 'fast' or 'moderately fast.'

It may be noticed that Madder, Munjeet, and Purpurin give faster colours with tin than with aluminium mordant.

SILK PATTERNS.

All the foregoing colours were also dyed on silk, and the patterns were exposed to light, along with those on wool, with the result that the relative fastness of the various colours was practically the same as on wool.

The only exceptions were the colours obtained from Morinda-root and from Kamála. Morinda yellow, dyed without the aid of any mordant, is much faster on silk than on wool, and although the colour becomes brownish during exposure, it may be classed as 'fast' on silk.

The Indian dyestuff Kamála was reported upon last year and classed as a 'fugitive' colour. This year the orange-yellow colour exposed was obtained by applying it in conjunction with alum, and found to be much faster than the colour obtained by dyeing in a simple alkaline bath (Na_2CO_3). A sample of the rich red-orange colour *dyed in India* was also exposed. Both dyes examined this year may be classed as 'moderately fast.'

Isomeric Naphthalene Derivatives.—Ninth Report of the Committee, consisting of Professor W. A. TILDEN *and* Professor H. E. ARMSTRONG. (*Drawn up by* Professor ARMSTRONG.)

IN previous reports reference has frequently been made to the trichloronaphthalenes: during the past year Dr. Wynne and the writer have at length completed their examination of this series, and have satisfied themselves of the existence of 14, but only 14, such compounds, which is in accordance with theory. A complete table of the 14 trichloronaphthalenes having been published in the 'Chemical Society's Proceedings,' No. 151, 1895, p. 85, it is unnecessary here to further refer to them.

It may be mentioned that the series is the largest hitherto known isomeric series.

In completing the work on this subject not only have numerous preparations been required, but it has been necessary also to make many chlorine determinations, and the grant has been expended chiefly on these latter. I am specially indebted to Mr. R. L. Jenks for his assistance in the analytical work.

Wave-length Tables of the Spectra of the Elements and Compounds.—Report of the Committee, consisting of Sir H. E. Roscoe (*Chairman*), Dr. Marshall Watts (*Secretary*), Mr. J. N. Lockyer, Professors Dewar, G. D. Liveing, A. Schuster, W. N. Hartley, *and* Wolcott Gibbs, *and* Captain Abney. (*Drawn up by* Dr. Watts.)

Table of Standard Wave-lengths (in air at 20° C. and 760 mm.).

[See Explanatory Note, p. 294.]

Rowland: 'Astronomy' and 'Astro-Physics,' 1893, xii. 321.

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ +	$\frac{1}{\lambda}$ −	
? .		4			1		7714·686	2·09	3·5	12958·8
? .		7			1		7699·374	2·08	,,	12984·6
[A_{11}] O .		7			3		7671·994	,,	,,	13030·9
O .		7			3		7670·993	,,	,,	13032·6
[A_{10}] O .		8			3		7666·239	,,	,,	13040·7
O .		8			3		7665·265	,,	,,	13042·4
[A_7] O .		14	III.		3		7660·778	2·07	,,	13050·0
O .		14	III.		3		7659·658	,,	,,	13051·9
[A_2] O .		14	III.		3		7628·585	,,	,,	13105·1
O .		14	III.		3		7627·232	,,	,,	13107·4
[A_1] O .		12	III.		4		7624·853	2·06	,,	13111·5
O .		12	III.		4		7623·526	,,	3·6	13113·7
[A†] O .		10	II.		5		7621·277	,,	,,	13117·6
[A*] O .					4		7594·059	,,	,,	13164·6
? .		3			1		7545·921	2·04	,,	13249·2
? .		6			3		7511·286	2·03	,,	13309·7
? .		6			3		7495·351	,,	,,	13338·0
? .		6			2		7462·609	2·02	,,	13396·5
? .		6			3		7446·038	,,	,,	13426·4
? .		6			2		7409·554	2·01	,,	13492·5
? .		7			2		7389·696	2·00	3·7	13528·7
? .		2			3		7331·206	1·99	,,	13636·6
? .		2			3		7321·056	1·98	,,	13655·5
wv ? .		5″			4		7318·818	,,	,,	13659·7
wv ? .		7			4		7304·475	,,	,,	13686·5
wv ? .		4			3		7300·056	,,	,,	13694·8
wv ? .		10″			3		7290·714	,,	,,	13712·4
wv ? .		6			3		7287·689	,,	,,	13718·1
wv ? .		8			4		7273·256	1·97	,,	13745·3
? .		3			2		7270·205	,,	,,	13751·1
wv ? .		8			3		7265·833	,,	,,	13759·3
wv ? .		8			3		7264·851	,,	,,	13761·2
wv ? .		4			2		7247·461	1·96	,,	13794·2
wv ? .		15	III.		4		7243·904	,,	,,	13801·0
wv ? .		4			5		7240·972	,,	,,	13806·6
? .		8	III.		4		7233·171	,,	,,	13821·5
? .		3			3		7232·509	,,	,,	13822·8
? .		6			4		7227·765	,,	,,	13831·8
? .		8	III.		5		7223·930	,,	,,	13839·2
wv ? .		6			4		7216·812	,,	,,	13852·8

* Beginning of head of A, outside edge. † Single line at the beginning of the tail of A.

TABLE OF STANDARD WAVE-LENGTHS—*continued*.

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	1/λ −	
wv .		10	III.		5		7201·468	1·95	3·8	13882·3
wv .		10	III.		5		7200·753	,,	,,	13883·6
wv .		7			3		7193·921	,,	,,	13896·8
wv ? .		5″			6		7186·552	,,	,,	13911·1
wv ? .		4			7		7184·781	,,	,,	13914·5
wv ? .		3			6		7176·347	,,	,,	13930·9
? .		3			5		7168·191	1·94	,,	13946·7
? .		7	II.		4		7148·427	,,	,,	13985·3
? .		1			4		7147·942	,,	,,	13986·2
? .		6	II.		5		7122·491	1·93	,,	14036·2
? .		4	II.		5		7090·645	1·92	,,	14099·3
? .		4	III.		10		7040·058	1·91	,,	14200·6
? .		2			6		7038·470	,,	,,	14203·8
? .		6	II.		8		7035·159	,,	,,	14210·5
? .		3			7		7027·726	,,	,,	14225·6
? .		1			1		7027·199	,,	,,	14226·6
? .		3″	IV.		2		7024·988	1·90	,,	14231·1
? .		3	IV.		7		7023·747	,,	,,	14233·6
? .		4	IV.		1		7023·225	,,	,,	14234·5
wv ? .		6	IV.		9		7016·690	,,	3·9	14247·8
wv ? .		3	IV.		5		7016·279	,,	,,	14248·7
? .		3	III.		6		7011·585	,,	,,	14258·2
? .		5	IV.		5		7006·160	,,	,,	14269·3
? .		4	III.		3		7000·143	,,	,,	14281·5
wv ? .		5″	IV.		6		6999·174	,,	,,	14283·5
wv ? .		5	III.		7		6989·240	,,	,,	14303·8
wv .		5	II.		10		6986·832	1·89	,,	14308·7
? .		2			5		6978·655	,,	,,	14325·5
wv ? .		6	III.		12		6961·518	,,	,,	14360·8
wv ? .		3	III.		10		6959·708	,,	,,	14364·5
wv .		8	I.		12		6956·700	,,	,,	14370·7
? . wv ? .		1 2 } ″	IV.		4		6953·838	,,	,,	14376·6
wv ? .		8	I.		10		6947·781	1·88	,,	14389·2
[B_{12}] { O .		1	III.		5		6935·530	,,	,,	14414·6
O .		1	III.		4		6934·646	,,	,,	14416·4
[B_{11}] { O .		2	II.		8		6929 838	,,	,,	14426·4
O .		2	II.		5		6928·992	,,	,,	14428·2
[B_{10}] { O .		3	I.		11		6924·420	,,	,,	14437·7
O .		3	I.		8		6923·557	,,	,,	14439·5
[B_9] { O .		4	I.		9		6919·245	,,	,,	14448·5
O .		4	I.		5		6918·363	,,	,,	14450·4
? .		2	II.		5		6916·957	,,	,,	14453·3
Ni . .	5	3	II.		4		6914·819	,,	,,	14457·8
[B_8] { O .		5	I.		4		6914·328	,,	,,	14458·8
O .		5	I.		5		6913·454	,,	,,	14460·6
[B_7] { O .		6	I.		9		6909·675	1·87	,,	14468·6
O .		6	I.		5		6908·785	,,	,,	14470·4
[B_6] { O .		6	I.		5		6905·263	,,	,,	14477·8
O .		6	I.		5		6904·358	,,	,,	14479·7
[B_5] { O .		6	I.		8		6901·113	,,	,,	14486·5
O .		6	I.		6		6900·199	,,	,,	14488·4
[B_4] { O		6	I.		8		6897·195	,,	,,	14494·7
O		6	I.		7		6896·292	,,	,,	14496·6

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$−	
[B_3] O .		6	I.		5		6893·559	1·87	3·9	14502·4
O .		6	I.		5		6892·614	,,	,,	14504·4
[B_2] O .		5	I.		5		6890·149	,,	,,	14509·6
O .		5	I.		5		6889·194	,,	,,	14511·6
[B_1] O .		5	I.		12		6886·987	,,	,,	14516·2
O .		5	I.		12		6886·008	,,	,,	14518·3
[B] O .		4	I.		13		6884·083	,,	,,	14522·4
Cr . .	3	1	III.		5		6883·318	,,	,,	14524·0
Cr . .	2	1	III.		5		6882·772	,,	,,	14525·1
Cr . .	1	1	III.		5		6881·970	,,	,,	14526·8
[B] O .		3	I.		11		6880·176	,,	,,	14530·6
O .		5	I.		11		6879·294	,,	,,	14532·5
[B] O .		5	I.		7		6877·878	,,	,,	14535·5
O .		5	I.		7		6876·957	,,	,,	14537·4
[B] O .		5	I.		9		6875·826	,,	,,	14539·8
O .		5	I.		5		6874·884	,,	,,	14541·8
O .		5	I.		5		6874·039	,,	,,	14543·6
[B] O .		5	I.		4		6873·076	1·86	,,	14545·6
O .		5	I.		5		6872·493	,,	,,	14546·9
[B] O .		5	II.		6		6871·527	,,	,,	14548·9
O .		5	II.		6		6871·179	,,	,,	14549·6
[B*] O .		{4, 4}″	I.		12		6870·186	,,	,,	14551·7
[B] O .		4 } ″	II.		5		6869·347	,,	,,	14553·5
O .		4 }	II.		5		6869·141	,,	,,	14554·0
[B] O .		{3, 1}″	IV.		3		6868·779	,,	,,	14551·7
O .		6″	III.		2		6868·393	,,	,,	14555·5
O .		1	IV.		2		6868·124	,,	,,	14556·1
[B†] O .		3	II.		11		6867·800	,,	,,	14556·8
O .		3	II.		11		6867·461	,,	,,	14557·5
Fe . .		3	II.		10		6855·425	,,	,,	14583·1
Fe . .		3	II.		5		6843·908	,,	,,	14607·6
Fe . .		3	II.		6		6841·591	,,	,,	14612·6
Fe . .		2	II.		7		6828·850	1·85	4·0	14639·7
Fe . .		2	II.		5		6820·614	,,	,,	14657·4
Fe . .		3	I.		8		6810·519	,,	,,	14679·2
Fe . .		2	II.		6		6807·100	,,	,,	14686·5
Fe . .		1	III.		5		6787·137	1·84	,,	14729·7
Ni . .	2	3	II.		10		6772·565	,,	,,	14761·5
Ni . .	5	4	I.		9		6768·044	,,	,,	14771·3
Fe . .		2	II.		7		6752·962	1·83	,,	14804·3
Fe . .		4	I.		12		6750·412	,,	,,	14809·9
Fe . .		3	III.		7		6726·923	,,	,,	14861·6
? .		3	III.		10		6722·095	,,	,,	14872·3
Ca . .	10	5	III.		10		6717·934	1·82	,,	14881·5
Li‡ . .	75		M.	3		6708·070		,,	,,	14903·4
? .		3	III.		12		6705·353	,,	,,	14909·5
? . .		2	III.		10		6703·813	,,	,,	14912·9

* The principal line in the head of B, a difficult double.

† These two lines are at the beginning of the head of B. There is a fine line midway between them.

‡ A difficult triplet.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ +	1/λ −	
Fe . .		5	I.		10		6678·232	1·81	4·0	14970·0
Fe . .		4 } "	I.		6		6663·696	,,	4·1	15002·6
? . .		1 }	I.		4		6663·525	,,	,,	15003·0
Ni . .	5	5	I.		10		6643·882	1·80	,,	15047·3
Fe . .		3	III.		7		6633·992	,,	,,	15069·8
Fe . .		4	I.		9		6609·345	,,	,,	15126·0
Fe . .		4	I.		12		6594·115	1·79	,,	15160·9
Fe . .		5	I.		11		6593·161	,,	,,	15163·1
Fe . .		4	IV.		7		6575·179	,,	,,	15204·6
? . .		2	III.		5		6574·477	,,	,,	15206·2
wv . .		1	III.		6		6572·312	,,	,,	15211·2
Fe . .		6	I.		13		6569·461	1·78	,,	15217·8
[C]H .		30	I.		13		6563·054	,,	,,	15232·7
wv . .		2	III.		6		6552·840	,,	,,	15256·5
Fe . . Ti . .	? 3	} 6	I.		11		6546·486	,,	,,	15271·3
? . .		3	I.		12		6534·173	,,	,,	15300·1
wv . .		1	III.		7		6532·546	1·77	,,	15303·9
Fe . .		4	II.		10		6518·594	,,	,,	15336·6
? . .	6	4	III.		7		6516·315	,,	,,	15342·0
Ca . .	5	5	I.		10		6499·871	,,	4·2	15380·7
Fe . .		7	I.		9		6495·209	,,	,,	15391·8
Ca . .	8	6	I.		10		6494·001	1·76	,,	15394·6
? . .		4	I.		8		6482·099	,,	,,	15422·9
wv . .		1	III.		6		6480·264	,,	,,	15427·3
Ca . .	5	5	I.		7		6471·881	,,	,,	15447·2
Fe . . Ca . .	? 10	3 } " 9 }	} I.		9		6462·835	,,	,,	15468·9
Ca . .	5	6	I.		6		6450·029	1·75	,,	15499·6
Ca . .	10r	7	I.		11		6439·298	,,	,,	15525·4
Cd . .			M.	1		6438·680		,,	,,	15526·9
Fe . .		6	I.		10		6431·063	,,	,,	15545·3
Fe . .		6	III.		10		6421·569	,,	,,	15568·3
Fe . .		5	I.		8		6420·171	,,	,,	15571·7
Fe . .		7	I.		10		6411·864	1·74	,,	15591·9
Fe . .		6	I.		8		6408·231	,,	,,	15600·7
Fe . .		3	IV.		6		6400·509	,,	,,	15619·6
Fe . .		8	IV.		5		6400·200	,,	,,	15620·3
Fe . .		7	I.		9		6393·818	,,	,,	15635·9
Fe . .		4	I.		6		6380·951	1·73	,,	15667·4
Ni . .	5	2	IV.		2		6378·461	,,	,,	15673·6
Fe . .		6	I.		8		6358·902	,,	4·3	15721·7
Fe . .		5	III.		8		6355·259	,,	,,	15730·7
Fe . .		5	I.		6		6344·370	,,	,,	15757·7
Fe . .		6	I.		12		6337·042	1·72	,,	15775·9
Fe . .		6	I.		12		6335·550	,,	,,	15779·6
Fe . .		5	I.		13		6322·912	,,	,,	15811·2
Fe-(Ca) .		6	I.		14		6318·242	,,	,,	15822·9
Fe . .		3	IV.		5		6315·541	,,	,,	15829·7
Ni . .	6	4	I.		7		6314·874	,,	,,	15831·3
Fe . .		7	I.		7		6301·719	1·71	,,	15864·4
O . .		3	I.		7		6296·144	,,	,,	15878·4
O* . .		3	III.		6		6293·152	,,	,,	15886·0

* Second line in the second pair of tail of *a*.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character In Arc	Intensity and Character In Sun	Kind of Standard	Weight In Arc	Weight In Sun	Wave-lengths In Arc (a)	Wave-lengths In Sun (b)	Reduction to Vacuo λ+	Reduction to Vacuo 1/λ −	Oscillation Frequency in Vacuo
O*		2	II.		5		6289·608	1·71	4·3	15894·9
O		2	II.		7		6281·374	,,	,,	15915·8
[a] O†		4″	I.		9		6278·289	,,	,,	15923·6
Fe		3	I.		10		6270·439	,,	,,	15943·5
Fe		5	I.		11		6265·347	1·70	,,	15956·5
Ti	5	2	I.		9		6261·316	,,	,,	15966·8
Fe }	?	} 6	I.		8		6256·574	,,	,,	15978·9
Ni }	7									
Fe‡		7	I.		9		6254·454	,,	,,	15983·8
Fe		7	I.		9		6252·776	,,	,,	15988·6
Fe		7	I.		9		6246·530	,,	,,	16004·6
?		4	I.		8		6237·529	,,	,,	16027·7
Fe-Va	?-6	7	I.		12		6230·946	1·69	,,	16044·6
Fe		6	I.		10		6219·493	,,	4·4	16074·1
Fe		6	I.		9		6213·646	,,	,,	16089·2
Fe		6	I.		10		6200·533	,,	,,	16123·2
Fe		8	I.		10		6191·770	1·68	,,	16146·1
Ni	4	6	I.		9		6191·397	,,	,,	16147·0
Fe		6	I.		8		6180·419	,,	,,	16175·7
Ni	5	6	I.		8		6177·028	,,	,,	16184·6
Fe		6	I.		8		6173·554	,,	,,	16193·7
Ca	7	7	I.		8		6169·775	,,	,,	16203·6
Ca	6	6	I.		4		6169·260	,,	,,	16205·0
Ca	15r	10	I.		9		6162·383	,,	,,	16223·1
Na		5	I.		4		6160·970	,,	,,	16226·8
Na		3	I.		5		6154·431	1·67	,,	16244·0
Fe-Ba	?-15	7	I.		9		6141·934	,,	,,	16277·1
Fe		8	II.		9		6136·834	,,	,,	16290·6
Ca	15r	9	I.		11		6122·428	,,	,,	16329·0
Fe	5	6	I.		8		6116·415	1·66	,,	16345·0
Ni	4	3	II.		8		6111·287	,,	,,	16358·8
Ni	5	6	I.		8		6108·338	,,	,,	16366·7
Li	20		M.	4		6103·812		,,	,,	16378·8
? }		1	} IV.		8		6103·449	,,	,,	16379·8
Fe }		4								
Ca	10r	6	I.		9		6102·941	,,	,,	16381·1
Fe		4	II.		4		6102·408	,,	,,	16382·6
Fe		3	I.		12		6079·223	1·65	4·5	16445·0
Fe		5	I.		13		6078·709	,,	,,	16446·4
Fe		7	I.		13		6065·708	,,	,,	16481·6
Fe		5	I.		9		6056·232	,,	,,	16507·4
Fe		4	I.		8		6042·316	1·64	,,	16545·4
Fe		4	I.		7		6027·265	,,	,,	16586·8
Fe		6	I.		8		6024·280	,,	,,	16595·0
Mn	10	5	I.		6		6022·017	,,	,,	16601·2
Fe		5	} IV.		6		6020·347	,,	,,	16605·8
?		3								
Mn	10	6	I.		8		6016·856	,,	,,	16615·5
Mn	10	6	I.		5		6013·717	,,	,,	16624·1
Fe		6	I.		6		6008·782	,,	,,	16637·8

* First line of first pair in the tail of *a*.
† Chief line in the *a* group, a very close double.
‡ A difficult double.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	$\lambda +$	$\frac{1}{\lambda} -$	
Fe . .		4	I.		3		6008·196	1·64	4·5	16639·4
Fe . .		6	I.		7		6003·245	1·63	,,	16653·2
Fe . .		6	I.		7		5987·286	,,	,,	16697·6
Fe . .		6	I.		6		5985·044	,,	,,	16703·8
wv .		2	IV.		1		5977·254	,,	,,	16725·6
Fe . .		5	III.		13		5977·005	,,	,,	16726·2
Fe . .		4	I.		12		5975·576	,,	,,	16730·3
Fe . .		5	I.		12		5956·925	1·62	4·6	16782·6
Si . .		6	I.		14		5948·761	,,	,,	16805·6
Fe . .		6	I.		13		5934·883	,,	,,	16844·9
Fe . .		6	I.		14		5930·410	,,	,,	16857·6
wv .		6	I.		12		5919·855	1·61	,,	16887·7
Fe . .		5	I.		16		5916·475	,,	,,	16897·4
? wv. . Fe . .		5 4	} I.		17		5914·384	,,	,,	16903·3
Fe . .		5	I.		15		5905·895	,,	,,	16927·6
Fe ? } . wv } .		1 5	} IV.		13		5901·681	,,	,,	16939·7
Fe ? } . wv } .		1 3	} IV.		10		5898·395	,,	,,	16949·2
[D_1]Na .		10	I.		20		5896·154	,,	,,	16955·6
Ni* . .	3″	4	III.		14		5893·098	,,	,,	16964·4
[D_2]Na .		15	II.		20		5890·182	1·60	,,	16972·8
wv .		3	IV.		8		5889·854	,,	,,	16973·7
wv . Fe . .		4 6	} IV.		11		5884·048	,,	,,	16990·5
[D_3]He .							5875·982	,,	,,	17013·8
Fe . .		6	I.		16		5862·580	,,	,,	17052·7
Fe . .		6	I.		15		5859·810	,,	,,	17060·8
Ca . .	10	7	II.		14		5857·672	,,	,,	17067·0
Ba . .	10	5	I.		14		5853·903	1·59	,,	17077·9
Ni . .	3	3	II.		6		5831·832	,,	4·7	17142·6
Fe . .		6	IV.		14		5816·594	,,	,,	17187·5
Fe . .		5	I.		14		5809·437	,,	,,	17208·7
Fe . .		5	I.		7		5806·954	,,	,,	17216·0
Ni . .	7	5	I.		8		5805·448	1·58	,,	17220·5
Fe . .		5	I.		9		5798·400	,,	,,	17241·4
? . .		4	I.		10		5798·087	,,	,,	17242·4
Fe } Cr } .	10	7	I.		16		5791·207	,,	,,	17262·8
Cr . .	7	5	I.		13		5788·136	,,	,,	17272·0
Cr . .	6	4	I.		9		5784·081	,,	,,	17284·1
Cu ? Co ? .		7	I.		9		5782·346	,,	,,	17289·3
Fe . .		5	I.		9		5775·304	1·57	,,	17310·4
Si . .		5	I.		6		5772·360	,,	,,	17319·2
Fe . .		7	IV.		8		5763·215	,,	,,	17346·7
? } Ni } .		5	I.		9		5754·884	,,	,,	17371·8
Fe . .		5	I.		10		5753·342	,,	,,	17376·5
Fe . .		4	I.		10		5752·257	,,	,,	17379·8
Fe . .		3	III.		10		5742·066	,,	,,	17410·6
Fe . .		5	I.		10		5731·973	1·56	,,	17441·3

* An exceedingly close double.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ	$\frac{1}{\lambda}$ –	
Fe Ti }	3	} 5	I.		10		5715·309	1·56	4·8	17492·1
Ni }	5									
Mg*.		6	M. III.	4		5711·374	5711·318	,,	,,	17504·3*b*
Ni	5	5	} III.		8		5709·760	,,	,,	17509·1
Fe		6	} III.		6		5709·616	,,	,,	17509·5
Si		5	I.		4		5708·620	,,	,,	17512·6
Fe	4	5	I.		8		5701·769	1·55	,,	17533·6
Na		6	I.		7		5688·434	,,	,,	17574·7
Na	3	4	I.		9		5682·861	,,	,,	17592·0
Fe	2	3	I.		8		5679·249	,,	,,	17603·2
Ti	3	2	III.		8		5675·648	,,	,,	17614·3
Fe	3	5	I.		9		5662·745	1·54	,,	17654·5
Yt ?	1	4	I.		9		5658·096	,,	,,	17669·0
Fe	2	4	II.		9		5655·707	,,	,,	17676·5
Si		2	III.		9		5645·835	,,	,,	17707·4
Fe	2	3	I.		10		5641·661	,,	,,	17720·5
Fe	2	3	I.		5		5634·167	,,	,,	17744·0
Fe-Va	5, 2	4	I.		14		5624·768	1·53	,,	17773·7
Fe	2	2	I.		12		5624·253	,,	,,	17775·3
Fe	2	6	II.		10		5615·879	,,	,,	17801·8
Fe	2	2	II.		10		5615·526	,,	,,	17803·0
Fe }	5	5	}							
Ca } †	6	3	} II.		10		5603·097	,,	4·9	17842·4
Fe }	2	2	}							
Ca	5	4	M. I.	2	4	5601·502	5601·501	,,	,,	17847·5*b*
Ca	7	4	II.	2	4	5598·712	5598·715	,,	,,	17856·3*b*
Fe	3	2	II.	1	2	5598.563	5598·555	,,	,,	17856·8*b*
Ca	7r	5	M. III.	2	5	5594·689	5594·695	,,	,,	17869·2*b*
Ca	5	4	M. I.	2	5	5590·352	5590·342	1·52	,,	17883·1*b*
Ca	10r	6	M. I.	2	9	5588·977	5588·980	,,	,,	17887·4*b*
Ca	6	4	M. I.	2	9	5582·204	5582·195	,,	,,	17909·2*b*
Fe	5	4	I.		7		5576·319	,,	,,	17928·1
Fe	6	5	I.		8		5569·848	,,	,,	17948·9
Fe	4	3	II.		8		5555·113	,,	,,	17996·5
Fe	3	2	I.		9		5544·158	1·51	,,	18032·1
Fe	3	2	I.		8		5543·418	,,	,,	18034·5
Fe		2	I.		8		5535·073	,,	,,	18061·7
Mg‡.	10	7	I.	4	8	5528·672	5528·636	,,	,,	18082·7*b*
Ca	5	3	III.	1	8	5513·127	5513·207	1·50	,,	18133·4*b*
Fe	5	4	I.		8		5507·000	,,	,,	18153·8
Fe	5	4	I.		8		5501·685	,,	5·0	18171·2
Fe	3	4	I.		8		5497·731	,,	,,	18184·3
Fe	2	3	II.		5		5487·968	,,	,,	18216·7
Ni	15r	4	I.		10		5477·128	,,	,,	18252·7
Fe	3	3	I.		10		5466·608	1·49	,,	18287·9
Fe	3	4	I.		10		5463·493	,,	,,	18298·3
Fe	3	4	I.		9		5463·174	,,	,,	18299·4

* Not recommended as a standard *in the arc.*

† Fe 5603·180 }
Ca 5603·080 }
Fe 5602·995 }

‡ In the arc this line is diffuse on one side. The solar line corresponds to the edge of the band-like line.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character In Arc	Intensity and Character In Sun	Kind of Standard	Weight In Arc	Weight In Sun	Wave-lengths In Arc (a)	Wave-lengths In Sun (b)	Reduction to Vacuo $\lambda +$	Reduction to Vacuo $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
Ni . .	3	1	II.		7		5462·732	1·49	5·0	18300·9
Fe } .	6	6	III.		1		5455·826	,,	,,	18324·0
} .			II.		8		5455·759	,,	,,	18324·3
Fe ? } .		3	III.		1		5455·666	,,	,,	18324·6
Fe* . .	7	7	I.	1	9	5447·116	5447·130	,,	,,	18353·3*b*
Fe . .	5	6	I.	1	9	5434·725	5434·742	1·48	,,	18395·1*b*
Fe . . Va . .	5 3	} 7	I.		10		5424·284	,,	,,	18430·6
Va . . Fe . .	4 4	} 6	I.		12		5415·421	,,	,,	18460·8
Cr . .	10r	5	I.		7		5410·000	,,	,,	18479·3
Fe . .	7	7	I.	1	14	5405·979	5405·987	,,	,,	18493·0*b*
Fe . .	7	7	I.	1	12	5397·319	5397·346	1·47	5·1	18522·5*b*
Fe . .	4	5	I.		11		5393 378	,,	,,	18536·2
Fe . .	3	4	I.		11		5389·683	,,	,,	18548·9
Fe . .	6	6	I.		11		5383·576	,,	,,	18569·9
Fe . .	2	3	I.		9		5379·776	,,	,,	18583·0
Fe-Cr } † . Ni } .	9, 2 2	7 2	} IV.		8		5371·686	,,		18611·0
Fe . .	4	6	I.		8		5370·165	,,	,,	18616·3
Fe . .	4	6	I.		8		5367·670	,,	,,	18625·0
?	?	3	IV.		1		5363·056	1·46	,,	18641·0
Fe (Co) }	1, 3	1	III.		5		5363·011	,,	,,	18641·1
? }		2	III.		7		5361·813	,,	,,	18645·3
Fe-Ni .	3, 3	4	IV.		8		5353·592	,,	,,	18673 9
Th ‡. .	75		M.	2		5350 670		,,	,,	18684·1
Ca . .	7	5	M. III.	1	4	5349·599	5349·623	,,	,,	18687·8*b*
Fe ? . .	3	4	II.		9		5333·092	,,	,,	18745·7
Fe . .	9	8	I.		8		5324·373	1·45	,,	18776·4
Co ? . } .	2	3	III.		1		5316·950	,,	,,	18802·7
[1474] } .		6	III.		7		5316·870	,,	,,	18803·0
Fe ? . } §.		4	III.		1		5316·790	,,	,,	18803·2
Fe . .	3	4	I.		10		5307·546	,,	,,	18836·0
Cr . .	2	3	I.		9		5300·918	,,	5·2	18859·5
Cr . .	6r	4	I.		12		5296·873	,,	,,	18873·9
Fe . .	2	2	I.		12		5288·708	1·44	,,	18903·0
Fe . .	5	6	I.		11		5283·803	,,	,,	18920·6
Fe . .	4	5	I.		11		5281·968	,,	,,	18927·1
Co . . Cr . . ?	3 5 ?	1 2 2	} I.		11		5276·205	,,	,,	18947·8
Fe } .	3	3	I.		8		5273·554	,,	,,	18957·3
} .	6		II.		5		5273·443	,,	,,	18957·7
Fe } .	3	3	I.		6		5273·344	,,	,,	18958·1
Fe } .	6	4	M. III.		3		5270·533	,,	,,	18968·2
[E_1] } .			I.		12		5270·495	,,	,,	18968·3
Ca } .	10	4	M. III.	2	3	5270·445	5270·448	,,	,,	18968·5*b*
E_2 Fe* .	8	8	I.	1	16	5269·714	5269·722	,,	,,	18971·1*b*

* A difficult double.

† The red component, a difficult double. ‡ A difficult triplet.

§ The 1474 lines is a triplet, or rather a double, the red component of which has a weak side-line to the violet; probably the violet component is due to iron, and the weak line to cobalt, but the red is unknown.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	$\lambda+$	$\frac{1}{\lambda}-$	
[Fe	6	6	I.	1	8	5266·733	5266·729	1·44	5·2	18981·9*b*
Cr (Ni ?)	4r	2	III.		1		5265·884	,,	,,	18985·0
		5	III.		2		5265·789	,,	,,	18985·3
Ca	8	3	III.	1	2	5265·725	5265·727	,,	,,	18985·5*b*
Ca	6	3	M. III.	2	3	5264·408	5264·395	,,	,,	18990·3*b*
		6	I.		2		5264·371	,,	,,	18990·4
Cr	4r	3	III.		3		5264·327	,,	,,	18990·6
Ca	6	2	III.	2	5	5262·408	5262·391	,,	,,	18997·6*b*
?		1	M. IV.		1		5262·341	,,	,,	18997·7
Cr Ca	2 6	3	III.	1	12		5261·880	,,	,,	18999·4
Ca	2	1	M. IV.	1	5	5260·556	5260·557	,,	,,	19004·2*b*
Fe	2	3	I.		12		5253·649	,,	,,	19029·2
Fe	3	3	I.		11		5250·825	1·43	,,	19039·4
Fe	2	2	I.		11		5250·391	,,	,,	19041·0
Fe	3	3	I.		10		5242·662	,,	,,	19069·1
Fe	7	8	I.		9		5233·124	,,	,,	19103·8
Fe	4	4	I.		8		5230·014	,,	,,	19115·2
Fe	2	2	I.		10		5225·690	,,	,,	19131·0
Fe	3	4	I.		10		5217·559	,,	,,	19160·8
Fe	3	4	I.		10		5215·352	,,	,,	19169·0
Ti	10r	3	M. I.	2	12	5210·549	5210·556	1·42	,,	19186·6*b*
Fe Cr	3 8r	3 4	I.		10		5204·708	,,	5·3	19208·1
Fe ?	4 ?	3 2	I.		11		5202·483	,,	,,	19216·3
Fe	3	4	I.		10		5198·885	,,	,,	19229·6
Ti	8	3	M. I.	2	8	5193·134	5193·139	,,	,,	19250·9*b*
Ca			M. I.	1	3	5189·019	5189·020	,,	,,	19266·2*b*
	6	4	I.		7		5188·948	,,	,,	19266·4
Ti	2	4	I.		3		5188·863	,,	,,	19266·7
[b_1]Mg	40r	20	M. I.	2	11	5183·791	5183·792	,,	,,	19285·6*b*
Ti	10r	3	I.		11		5173·912	1·41	,,	19322·4
[b_2]Mg	35r	10	M. I.	2	9	5172·866	5172·871	,,	,,	19326·3*b*
Fe	5	5	I.		11		5171·783	,,	,,	19330·4
Fe	3	4	I.		3		5169·218	,,	,,	19340·0
[b_3]			I.		5		5169·161	,,	,,	19340·2
Fe	3	4	I.		3		5169·066	,,	,,	19340·5
Fe	6	6	M. IV.	2	3	5167·664	5167·686	,,	,,	19345·7*b*
[b_4]			III.		7		5167·572	,,	,,	19346·1
Mg	20r	8	M. IV.	2	3	5167·488	5167·501	,,	,,	19346·4*b*
Fe	2	2	I.		10		5165·588	,,	,,	19353·6
C*		1	M.	2	1	5165·241	5165·190	,,	,,	19354·9*a*
Fe	4	4	I.		13		5162·448	,,	,,	19365·4
Fe ?		2	I.		11		5159·240	,,	,,	19377·4
Ni	6	2	I.		10		5155·937	,,	,,	19389·8
Ti ? Co ?		2	I.		10		5154·237	,,	,,	19396·2
Mn Fe	2 4	1 3	III.		9		5151·026	,,	,,	19408·3
? Ni	? 5	3	I.		10		5146·664	,,	,,	19424·8

* the arc the first line of the first head of the green carbon band.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave Lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	+λ	$\frac{1}{\lambda}$ −	
Fe }			IV.		2		5143·106	1·41	5·3	19438·2
	3	4	IV.		5		5143·042	,,	,,	19438·4
Ni	5	2	IV.		1		5142·967	,,	,,	19438·7
Fe	2	3	I.		5		5141·916	,,	,,	19442·7
Fe }			III.		4		5139·645	,,	,,	19451·3
	5	6	III.		4		5139·539	,,	,,	19451·7
Fe	4	6	III.		4		5139·437	,,	,,	19452·1
? }	?	6	I.		12		5133·871	1·40	,,	19473·2
Fe	1									
Fe	4	4	I.		9		5127·530	,,	,,	19497·3
Co	3	2	I.		9		5126·369	,,	,,	19501·7
Fe }	3	3	IV.		9		5121·797	,,	,,	19519·1
Ni	2	1								
Ni	5	2	I.		9		5115·558	,,	5·4	19542·8
Fe }	4	3	II.		11		5110 570	,,	,,	19561·9
?	?	2								
Fe	3	2	I.		11		5109·825	,,	,,	19564·7
Fe (Cu)	3 ?	3	I.		12		5105·719	,,	,,	19580·5
Fe	3	2	IV.		7		5097·176	1·39	,,	19613·3
Fe	3	2	I.		9		5090·959	,,	,,	19637·3
Cd		?	M.	1		5086·001		,,	,,	19656·4
Fe	4	3	I.		9		5083·525	,,	,,	19666·0
Fe	4	4	I.		14		5068·946	,,	,,	19722·6
Ti	10	3	II.		12		5064·833	,,	,,	19738·6
Fe	2	2	II.		15		5060·252	1·38	,,	19756·5
Fe	5	5	I.		12		5050·008	,,	,,	19796·5
Ca	3	2	M.	2	1	5041·867	5041·795	,,	,,	19828·5*a*
Ni }	3	2	II.		8		5036·113	,,	,,	19851·2
Ti	6	3								
Ti	7	3	II.		8		5020·210	1·37	5·5	19914·0
Ti }	5	4	M. II.		10	5014·412	5014·422	,,	,,	19937·5*b*
(Ni) Ti	?-10	3								
Mg b'd*			M.	3	10	5007·473		,,	,,	19964·6
Nebula						5007·05		,,	,,	19966·3
Fe }	3	3	I.		10		5007·431	,,	,,	19964·8
Ti	10r	4								
Fe		6	I.		8		5006·303	,,	,,	19969·3
Fe	3	4	II.		10		5005·904	,,	,,	19970·9
Pb			M.	5		5005·634		,,	,,	19972·0
Ti-La	10r 10r	4	M. III.		8	4999·668	4999·693	,,	,,	19995·7*b*
Fe	3	4	I.		7		4994·316	,,	,,	20017·3
Ti	10	4	III.	1	10	4981·893	4981·915	1·36	,,	20067·1*b*
? }	?	1	III.		5		4980·362	,,	,,	20073·4
Ni	5	3								
Fe }	3	3	I.		8		4978·782	,,	,,	20079·7
?		1								
Fe	3	3	I.		10		4973·274	,,	,,	20102·0
Ti	1									
Nebula						4959·02		,,	,,	20159·8
Fe		8	M. IV.		3		4957·786	,,	,,	20164·8
Fe		6	M. IV.		3		4957·482	,,	,,	20166·0

* Commencement of the head of Mg band.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$ −	
Ba*	60	7	M. III.	1	10	4934·237	4934·247	1·35	5·6	20260·9*b*
Fe	3	2	I.		12		4924·955	,,	,,	20299·2
Fe	2	4	II.		13		4924·109	,,	,,	20302·6
Fe	9	9	M. I.	1	7	4920·676	4920·682	,,	,,	20316·8*b*
Fe	6	7	I.		4		4919·183	,,	,,	20323·0
Pb			M.	1		4905·634		1·34	,,	20379.1
Fe }	5		} I.		14		4903·488	,,	,,	20388·0
Cr }	2	6								
Yt		2	II.		11		4900·306	,,	,,	20401·3
Ti	4	2	II.		11		4900·098	,,	,,	20402·1
Fe	7	7	I.		11		4890·945	,,	,,	20440·3
[F] H		15	II.		5		4861·496	1·33	5·7	20564·1
Fe	4	5	I.		14		4859·934	,,	,,	20570·8
Fe?		4	I.		11		4824·325	1·32	,,	20722·6
Mn	10	6	M. I.	1	12	4823·715	4823·697	,,	,,	20725·3*b*
Zn		3	M. I.	1	1	4810·725	4810·723	,,	,,	20781·2*b*
Ti }	1	4	} IV.		3		4805·253	,,	,,	20804·8
? }	?	1								
Cd		?	M.	3		4800·097		1·31	,,	20827·2
Mn	10r	6	M. I.	1	1	4783·607	4783·601	,,	5·8	20898·9*b*
Mn	15r	6	I.		11		4754·226	1·30	,,	21028·1
Mn }	7	3	} III.		11		4727·628	1·29	,,	21146·5
Fe }	2	4								
Zn	4	4	M. I.	2	2	4722·339	4722·349	,,	,,	21170·1*b*
Ni	9r	6″	M. III.	1	1	4714·598	4714·599	,,	,,	21204·9*b*
Ni	3	3	I.		13		4703·986	,,	5·9	21252·7
Mg	5	9	I.	1	11	4703·249	4703·180	,,	,,	21256·3*b*
Fe }	3	4	} IV.		11		4691·581	1·28	,,	21308·9
Ti }	3	2								
?		4	II.		14		4690·324	,,	,,	21314·6
Ni	4	4	I.		12		4686·395	,,	,,	21332·5
Fe	2	3	I.		13		4683·743	,,	,,	21344·5
Zn		2	M.	1		4680·319		,,	,,	21360·2
Fe	3	6	II.		12		4679·028	,,	,,	21366·1
Cd		4?	M.	3	3	4678·339	4678·353	,,	,,	21369·1*b*
Fe }	3	5	} II.		11		4668·303	,,	,,	21415·2
? }	?	2								
Ni	6r	3	M. III.	1	1	4648·833	4648·835	1·27	,,	21504·9*b*
Fe	2	4	I.		17		4643·645	,,	,,	21528·9
Fe	3	4	II.		14		4638·194	,,	,,	21554·2
Fe	3	4	II.		14		4637·683	,,	,,	21556·6
Co }	5	} 5	II.		13		4629·515	,,	6·0	21594·5
Ti }	4									
Fe	4	6	} IV.		11		4611·453	1·26	,,	21679·1
? }	?	2								
Sr }	50r	2	M. II.	5	4	4607·506	4607·509	,,	,,	21697·7*a*
C†						4606·6		,,	,,	21702·0
Li	50r		M.	1		4602·25		,,	,,	21722·5
Fe	2	4	I.		20		4602·183	,,	,,	21722·8
Ti?		4	I.		15		4590·129	,,	,,	21779·9
Cr?		4	I.		14		4588·384	,,	,,	21788·2
Ca Ti	3, 1	4	I.	1	14	4578·807	4578·731	1·25	,,	21834·1*b*

* A difficult double. † First line in first head of blue cyanogen band (ζ).

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	1/λ −	
Ti	5	6	I.		14		4572·157	1·25	6·0	21865·5
Mg	3	5	I.	1	14	4571·281	4571·277	,,	,,	21869·7*b*
Ti	4	6	I.		13		4563·939	,,	6·1	21904·8
Ba	70r	7	M. I.	6	8	4554·212	4554·213	,,	,,	21951·6*b*
In			M.	3		4513·883		1·24	,,	22147·8
In			M.	4		4511·474		,,	,,	22159·6
Ti ?		4	I.		17		4508·456	,,	,,	22174·4
C						4502·6		1·23	,,	22203·3
Ti	6	5	II.		18		4501·444	,,	,,	22909·0
? }		1	II.		7		4499·315	,,	,,	22219·5
Mn }		2	I.		8		4499·070	,,	,,	22220·7
Zr }	2	1	} IV.		14		4497·041	,,	6·2	22230·7
Cr }	5	4		1						
Fe		5	I.	2	18	4494·756	4494·735	,,	,,	22242·0
Ca	1	1	M. IV.	5	2	4456·791	4456·793	1·22	,,	22431·5
Ca	3r	2	M.	6	3	4456·055	4456·047	,,	,,	22435·2*a*
Ca	6r	6	M. IV.	2	6	4454·949	4454·950	,,	,,	22440·7*b*
Fe	8	5	I.	5	18	4447·912	4447·899	,,	,,	22476·3*b*
Ca	4r	3	M. I.	5	6	4435·856	4435·852	,,	,,	22537·4*b*
Ca	5r	4	M. III.	5	5	4435·133	4435·132	,,	,,	22541·0*b*
Ca	5r	4	M. I.	9	7	4425·616	4425·609	1·21	6·3	22589·5*b*
Fe	4r	4	M. III.	3	7	4415·298	4415·299	,,	,,	22642·2*a*
Cd	6	6	M.			4413·181		,,	,,	22653·1
Fe }	3	3	} III.		19		4407·850	,,	,,	22680·5
Va }	9r	2								
Fe	10r	8	M. III.	10	11	4404·928	4404·927	,,	,,	22695·6*b*
Ti }	1	1	} III.		14		4391·149	1·20	,,	22766·8
Fe }	2	3								
[d] Fe	15r	10	M. II.	10	11	4383·721	4383·721	,,	,,	22805·4
Fe	5	5	I.	1	17	4376·108	4376·103		,,	22845·1*b*
Fe	4	5	I.	1	14	4369·948	4369·943		,,	22877·3*b*
Zr }	5	1	} III.		10		4359·778	,,	6·4	22930·5
Cr }	4	3								
Ni }	3	1								
Fe	4	3	I.	1	17	4352·908	4352·903	1·19	,,	22966·8*b*
Fe }	2	2	} III.		11		4343·387	,,	,,	23017·1
Cr }	2	1								
[f] Fe	10r	8	M. II.	8	15	4325·932	4325·940	,,	,,	23110·0*b*
Ca	4r	3	M. I.	3	16	4318·816	4318·818	1·18	,,	23148·1*b*
Fe }	7r	5	III.	8	10	4308·072	4308·071	,,	6·5	23205·7*b*
[G] }			III.		3		4308·034	,,	,,	23205·9*b*
Ca }	4r	2	III.	3	3	4307·906	4307·904	,,	,,	23206·6*b*
Ti	10r	4	M. III.	4	4	4306·071	4306·071	,,	,,	23216·5
Sr	8	2	M.	1		4305·636		,,	,,	23218·9
Ca	6r	4	M.	5	7	4302·690	4302·689	,,	,,	23234·8*b*
Ca	3r	2	M. III.	3	5	4299·153	4299·152	,,	,,	23253·9*b*
?		4	II.		14		4293·249	,,	,,	23285·9
Cr	10r	4	M. III.	2	2	4289·884	4289·881	,,	,,	23304·2*b*
Ca	4r	3	M. III.	3	5	4289·527	4289·523	,,	,,	23306·1*b*
Ca	5r	3	M. III.	2	4	4283·175	4283·170	,,	,,	23340·7*b*
Cr	15r	5	M. III.	1	2	4274·954	4274·958	1·17	,,	23385·5*b*
Fe	10r	8	M. III.	8	9	4271·920	4271·924	,,	,,	23402·2*b*
Fe }	1	2	} III.		12		4267·958	,,	,,	23423·9
? }	?	1								

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ +	$\frac{1}{\lambda}$ −	
Fe . .	6r	7	III.	4	3	4260·647	4260·638	1·17	6·5	23464·1*a*
Cr . .	20r	7	M. I.	2	15	4254·494	4254·502	,,	,,	23498·0*b*
Fe . .	5	7	II.	4	3	4250·949	4250·956	,,	6·6	23517·6*a*
Fe . .	4	5	II.	1	1	4250·300	4250·290	,,	,,	23521·2*b*
[*g*]Ca .	50r	10	M. III.	9	10	4226·898	4226·892	1·16	,,	23651·4*b*
Fe . .	2	4	I.	1	22	4222·396	4222·381	,,	,,	23676·7*b*
C* . .		1	M. III.	4	2	4216·133	4216·137	,,	,,	23711·8*a*
Sr } .	40r	4	M. III.	{ 6	3	4215·688	4215·687	,,	,,	23714·3*a*
					18		4215·667	,,	,,	23714·4
Fe } .	2	?2	III.		2		4215·616	,,	,,	23714·7
Fe . .	8	5	II.	2	4	4202·187	4202·188	1·15	,,	23790·5*b*
Fe } .	5	} 5	I.	2	22	4199·257	4199·263	,,	6·7	23807·0*b*
Zr } .	2									
C† . .		1	M. III.	5	6	4197·256	4197·251	,,	,,	23818·4*b*
Fe . .	4	3	I.		20		4185·063	,,	,,	23887·8
C . .			M.			4158·2		1·14	,,	24042·2
Fe . .	4	3	I.		17		4157·948	,,	,,	24043·6
Fe-Cr .	3, 1	3	II.		13		4121·968	1·13	6·8	24253·5
Co } ‡ .	10r	3	} III.	1	12	4121·476	4121·481	,,	,,	24256·3*b*
Cr } .	1	1								
Fe . .	3	4	I.		14		4114·600	,,	,,	24296·9
Fe . .	5	5	I.		12		4107·646	,,	,,	24338·0
Mn } .	1	} 6	I.		10		4103·101	,,	,,	24365·0
Si } .	3									
Fe . .	2	2	I.		8		4088·716	1·12	6·9	24450·7
Fe . .	2	2	III.		7		4083·928	,,	,,	24479·3
Mn } .	5	4	} III.		7		4083·767	,,	,,	24480·3
Fe } .	2	2								
Sr . .	50r	8	M. IV.	5	6	4077·876	4077·883	,,	,,	24515·6*b*
Fe . .	4	4	I.		14		4073·920	,,	,,	24539·5
Fe . .	10	10	M. IV.	7	9	4071·903	4071·904	,,	,,	24551·6*b*
Fe . .	15r	15	M. IV.	7	7	4063·755	4063·756	,,	,,	24600·9*b*
Fe . .	5	5	I.		8		4062·602	,,	,,	24607·9
Mn . .	8	5	I.		13		4055·701	,,	,,	24649·7
Cr } .	2	} 6	III.		13		4048·893	1·11	7·0	24691·1
Mn } .	8									
Zr } .	1									
K . .	40r	1?	M.	2		4047·373		,,	,,	24700·4
Fe . .	20r	20	M. IV.	7	7	4045·975	4045·975	,,	,,	24708·9
K . .	50r	1	M.	2	2	4044·301	4044·293	,,	,,	24719·2*b*
Mn . .	7	3	M.			4035·88	4035·88	,,	,,	24770·7
Mn . .	20r	5	M.	3	4	4034·642	4034·641	,,	,,	24778·2*b*
Mn . .	25r	6	M.	3	4	4033·230	4033·225	,,	,,	24787·1*b*
Mn . .	30r	7	M.	3	4	4030·919	4030·914	,,	,,	24801·3*b*
Zr } .	2	} 4	I.		10		4029·796	,,	,,	24808·1
Fe } .	2									
Fe . .		3	I.		7		4016·578	,,	,,	24889·8
Fe-?§ .	10	10	III.		3		4005·305	1·10	,,	24959·9
Ce-Fe-Ti .	4,1, 2	3	III.		9		4003·916	,,	,,	24968·5

* First line in first head of cyanogen band (*θ*).
† First line in second head of cyanogen band (*θ*). ‡ Cobalt line measured.
§ Seven or eight lines, the brightest and most of the others due to Fe.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character: In Arc	Intensity and Character: In Sun	Kind of Standard	Weight: In Arc	Weight: In Sun	Wave-lengths: In Arc (a)	Wave-lengths: In Sun (b)	Reduction to Vacuo: λ+	Reduction to Vacuo: 1/λ −	Oscillation Frequency in Vacuo
Co	2	6	III.		4		3987·216	1·10	7·1	25073·0
Mn	4									
?	?									
Mn	4	1	III.		9		3986·903	,,	,,	25075·0
?	?	7								
Fe	3	6	III.		9		3984·078	,,	,,	25092·8
Cr	5									
Fe-Ti	6?	4	III.		14		3981·914	,,	,,	25106·4
Fe	5	4	I.		15		3977·891	,,	,,	25131·8
Ca*	5	3	M.	1	2	3973·881	3973·835	1·09	,,	25157·5*b*
Fe	5	4	II.		11		3971·478	,,	,,	25172·4
H			M.			3970·05		,,	,,	25181·5
[H] Ca†	70r	200	M.	7	5	3968·617	3968·620	,,	,,	25190·6*a*
Al	30r	15	M. IV.	7	8	3961·680	3961·676	,,	,,	25234·7*b*
Fe	3	3	I.		11		3960·429	,,	,,	25242·7
Fe-Ca	5, 6	6	II.	1	2	3957·228	3957·180	,,	,,	25263·4*b*
Fe	2	2	II.		13		3954·001	,,	7·2	25283·6
Yt	10	2	III.		13		3950·497	,,	,,	25306·1
Fe	4	4	I.		15		3950·101	,,	,,	25308·6
Ca	4	2	M.	1	2	3949·070	3949·034	,,	,,	25315·4*b*
Al‡	20r	10	M. IV.	7	7	3944·165	3944·159	,,	,,	25346·7*b*
Fe	5	4	III.		15		3942·559	,,	,,	25357·0
?	?	2								
Fe-Co	4, 4	5	III.	1	15	3941·034	3941·021	,,	,,	25366·9*b*
Fe	3	4	II.		8		3937·474	,,	,,	25389·8
[K] Ca†	75r	300	M.	6	5	3933·809	3933·809	1·08	,,	25413·4
Fe	10r	8	M.	1	3	3928·060	3928·071	,,	,,	25450·6*b*
?	?	4	II.		12		3926·123	,,	,,	25463·2
Fe	5	4								
Fe	3	4	III.		13		3925·792	,,	,,	25465·4
Va	2	4	II.		15		3925·345	,,	,,	25468·3
Fe	1									
Ti	6	4	II.		15		3924·669	,,	,,	25472·7
Fe	3	3	II.	1	12	3916·886	3916·875	,,	7	25523·4*b*
Si	10r	10	M.	4	4	3905·670	3905·666	,,	7·3	25596·5*b*
Fe	3	4	II.		12		3897·599	,,	,,	25649·5
Fe	15r	9	M. IV.	7	6	3886·421	3886·427	1·07	,,	25723·3*a*
Cr		1	III.		12		3883·773	,,	,,	25740·9
C§			M. IV.		8	3883·523	3883·548	,,	,,	25742·3*b*
C‖		7	M. IV.	5	3	3883·479	3883 472	,,	,,	25742·8*a*
Va		3	III.		15		3875·224	,,	,,	25797·7
?										
C¶		4	M.	4	4	3871·527	3871·528	,,	,,	25822·3*b*
C**		3	II.		8		3864·441	,,	,,	25869·7
Fe	10r	10	M. IV.	2	3	3860·050	3860·048	,,	,,	25899·1*b*
Fe	6	7	M.	1	2		3856·517	1·06	,,	25922·8
Fe	4	5	III.		8		3843·406	,,	,,	26011·3
Fe	7r	7	M.	1	2	3840·589	3840·584	,,	,,	26030·4*b*
Mg	40r	20	M.		2		3838·430	,,	,,	26045·0

* Red component of double; the violet component is due to Fe.
† Solar line doubly reversed. ‡ Red component of triplet.
§ Edge of first head of cyanogen band (*i*). ‖ First line of first head of cyanogen band (*i*). ¶ Second head of cyanogen band (*i*). ** One of the lines in cyanogen band.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$ −	
C*		5	M. IV.	1	1	3836·638	3836·652	1·06	7·3	26057·1*b*
?-C		4	III.		8		3836·226	„	„	26060·0
Mg	30r	10	M.		2		3832·446	„	„	26085·7
Mg	20r	8	M.		2		3829·505	„	„	26105·7
Fe	8r	8	M.	1	1	3827·973	3827·973	„	„	26116·2
Fe	20r	20	M. III.	4	4	3826·024	3826·024	„	„	26129·4
Mn (Cr)	5, 1r	5	II.		10		3823·651	„	„	26145·7
Fe	5	6	II.		10		3821·318	„	„	26161·7
Fe	30r	30	M. III.	4	4	3820·566	3820·567	„	„	26166·8*b*
Fe	20r	20	M. III.	4	3	3815·984	3815·985	1·05	7·4	26198·2*a*
Fe-Di	4, ?	6	I.		15		3805·487	„	„	26270·4
Fe	2	3	I.		15		3804·153	„	„	26279·7
Fe	8	8	III.		2		3799·698	„	„	26310·5
Fe	7	7	III.		2		3798·662	„	„	26317·7
Fe	8	8	M.	3	4	3795·148	3795·150	„	„	26342·0*b*
Fe-Cr	1, 1	3	III.		15		3794·014	„	„	26349·9
Fe	7r	8	M. III.	3	3	3788·029	3788·032	„	„	26391·5*b*
Ni	10r	6	III.		15		3783·674	„	„	26421·9
Fe	2	3	II.		15		3781·330	„	„	26438·3
?		4	II.		15		3780·846	„	„	26441·7
Th	40r		M.	1		3775·869		1·04	„	26476·6
Yt ?	6	3	M. III.	1	1	3774·478	3774·480	„	„	26486·3*b*
Fe	3	4	III.		12		3770·130	„	7·5	26516·8
Fe	7r	8	M. III.	9	8	3767·342	3767·344	„	„	26536·4*a*
Fe	9r	10	M.	9	8	3763·939	3763·942	„	„	26560·4*a*
Fe	15r	15	M. III.	8	7	3758·380	3758·379	„	„	26599·7*a*
Fe	2	2	II.		12		3756·211	„	„	26615·1
? }		1	} III.		12		3754·664	„	„	26626·0
? }		2								
Fe	20r	20	M. III.	7	8	3749·633	3749·633	„	„	26661·8
Fe	10r	10	M. III.	7	8	3748·410	3748·409	„	„	26670·5*b*
? }	?	} 7	II.	1	9	3747·082	3747·095	„	„	26679·8*b*
Fe }	3									
Fe	7r	7	M.	6	5	3746·048	3746·054	„	„	26687·3*a*
Fe	10	10	M.	8	6	3745·708	3745·701	„	„	26689·7*a*
Cr }	3	2	}							
Fe } †	5	6	M. III	4	2	3743·506	3743·502	„	„	26705·4*a*
Ti }	3	2							„	
Fe	25r	30	M. III.	7	8	3737·280	3737·282	1·03	7	26749·9*b*
Ca	4r		M. IV.	2	3	3737·081	3737·075	„	„	26751·4*b*
Mn }	2	5	} IV.		2		3736·969	„	„	26752·2
Ni }	6	3								
Fe	40r	50	M. III.	8	7	3735·012	3735·014	„	„	26766·1*a*
Fe	6r	7	M. III.	5	3	3733·467	3733·467	„	„	26777·3
Fe	5	5	I.	1	15	3732·549	3732·542	„	„	26783·9*b*
Fe	6r	7	M.	5	3	3727·768	3727·763	„	7·6	26818·1*a*
Fe-Ti } †	8, 5	} 10	M. III.	7	5	3722·712	3722·691	„	„	26854·5*a*
Ni }	4									
Fe	40r	50	M. III.	11	10	3720·082	3720·086	„	„	26873·5*a*
Fe	4	7	I.	1	12	3716·601	3716·585	„	„	26898·8*b*
Yt	10r	3	M. III.	1	1	3710·442	3710·438	„	„	26943·4*b*

* Central line of symmetrical group. † Iron line measured.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$−	
Fe	10r	10	M. IV.	6	4	3709·395	3709·397	1·03	7·6	26951·0*a*
Fe	5	5	I.	1	11	3707·201	3707·186	,,	,,	26967·0*b*
Fe*	7r	8	M. III.	7	5	3705·715	3705·711	,,	,,	26977·7*a*
Fe	5	5	I.	1	11	3695·208	3695·194	1·02	,,	27054·6*b*
Yt		3	M. III.	1	1	3694·351	3694·349	,,	,,	27060·8*b*
Fe	10r	8	M. III.	8	6	3687·609	3687·607	,,	,,	27110·2*a*
Fe	5	6	I.	1	14	3684·268	3684·259	,,	,,	27134·9*b*
Pb	60r	1	M.	5		3683·622		,,	7·7	27139·5
Va }	4									
Fe } †	3	6	I.	1	13	3683·209	3683·202	,,	,,	27142·6*b*
Co }	9									
Fe	8r	8	M. III.	8	7	3680·064	3680·064	,,	,,	27165·7
Fe	5	3	I.		13		3667·397	,,	,,	27259·6
Fe }	2	2	I.		7		3658·688	,,	,,	27324·5
Mn }	2									
Ti	10r	4	M. II.	2	7	3653·639	3653·639	1·01	,,	27362·3
Co	5	3	I.		5		3652·692	,,	,,	27369·4
Fe	10r	10	M. III.	10	11	3647·995	3647·995	,,	,,	27404·6
Fe } †	5	5	M. I.	1	14	3640·545	3640·536	,,	,,	27460·8*b*
Cr }	2									
Pb‡	50r	1	M.	4		3639·728		,,	,,	27466·9
Fe	5	5	M. IV.	1	1	3638·454	3638·435	,,	7·8	27476·6*b*
Ti	10r	3	M. II.	3	1	3635·615	3635·616	,,	,,	27497·9*a*
Yt‡	5	3	M.	1	1	3633·277	3633·259	,,	,,	27515·7*b*
Fe	20r	20	M. IV.	11	10	3631·616	3631·619	,,	,,	27528.2*a*
Yt	3	2	M. III.	1	1	3628·853	3628·853	,,	,,	27549·1
Fe	2	3	I.		10		3623·603	,,	,,	27589·1
Fe	4	4	M. I.	1	14	3623·338	3623·332	,,	,,	27591·1*b*
Fe	4	4	M. IV.	2	3	3622·161	3622·147	,,	,,	27600·1*b*
Fe	4	4	M. III.	2	2	3621·616	3621·606	,,	,,	27604·3*b*
Yt	3	1	M.	1	1	3621·096	3621·122	,,	,,	27608·0*b*
Fe	20r	20	M. IV.	11	10	3618·922	3618·924	,,	,,	27624·7*a*
Fe } †	4	3	M. IV.	1	1	3617·939	3617·920	1·00	,,	27632·4*b*
Ca }		2								
Fe	4	4	IV.	1	15	3612·237	3612·217	,,	,,	27676·0*b*
Yt	7	3	M. III.	1	1	3611·196	3611·193	,,	,,	27683·9*b*
Fe	15r	15	M. III.	11	10	3609·015	3609·015	,,	,,	27700·6
Fe§	4	6	M.	2	2	3606·836	3606·831	,,	,,	27717·4*b*
Fe	5	7	M. IV.	2	2	3605·621	3605·635	,,	,,	27726·6*b*
Cr	10r	4	M. IV.	1	2	3605·497	3605·483	,,	,,	27727·7*b*
Yt	6	2	M. III.	1	1	3602·065	3602·061	,,	,,	27754·1*b*
Yt (Fe)	10?	4	M. I.	1	1	3600·884	3600·880	,,	,,	27763·2*b*
Fe	5	4	I.		12		3597·192	,,	,,	27791·7
C‖		3	M.	7		3590·523		,,	7·9	27843·2
C		2	M.	2		3586·041		,,	,,	27878·0
C¶	2	1	M.	8		3585·992		,,	,,	27878·4
Yt	6	2	M.	1	1	3584·662	3584·662	,,	,,	27888·7

* Violet component of double. † Iron line measured.

‡ Red component of double.

§ The solar line is a group of four; the second from the red is the brightest, and due to Fe.

‖ First line in first head of cyanogen band.

¶ First line in second head of cyanogen band.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$ −	
Fe ?	2	4	I.		12		3583·483	1·00	7·9	27897·9
Fe	30r	40	M. IV.	9	6	3581·344	3581·344	,,	,,	27914·6
Fe	10	10	M.	1	1	3570·412	3570·402	0·99	,,	28000·2*b*
Fe*	20r	20	M.	8	4	3570·253	3570·225	,,	,,	28001·3*a*
Fe	10r	12	M.	6	4	3565·530	3565·528	,,	,,	28038·4*a*
Fe }	1	} 4	I.		12		3564·680	,,	,,	28045·1
Ti }	2									
Fe	9r	8	M. III.	3	4	3558·674	3558·670	,,	,,	28092·5*b*
Fe	2	3	I.		7		3550·006	,,	8·0	28161·0
Yt	6	2	M. I.	1	1	3549·147	3549·145	,,	,,	28167·8*b*
?		4	I.		6		3545·333	,,	,,	28198·1
Fe	3	5	I.		10		3540·266	,,	,,	28238·5
Th	20r		M.	1		3529·547		0·98	,,	28324·3
Fe	5r	7	M.	6	5	3521·409	3521·404	,,	,,	28389·7*a*
Th	40r		M.	1		3519·342		,,	,,	28406·4
Co	6r	5	I.		10		3518·487	,,	,,	28413·3
Fe†	7r	6	M.	2	3	3513·981	3513·947	,,	,,	28450·0*b*
Ti	5	4	II.		8		3510·987	,,	,,	28474·0
Ni	7r	7	I.		4		3500 993	,,	8·1	28555·2
Fe	2	3	I.		4		3500·721	,,	,,	28557·5
? } †	?	3	} M.	5	4	3497·991	3497·991	0·97	,,	28579·7
Fe }	6r	7								
Fe*	5	5	M.	1	1	3497·266	3497·264	,,	,,	28585·7*b*
? }	?	} 4	I.		8		3491·464	,,	,,	28633·2
Co }	4r									
Fe	10r	10	M.	7	3	3420·724	3490·721	,,	,,	28639·3*a*
Ni	4r	5	II.		9		3486·036	,,	,,	28677·8
Ni }	2	} 4	I.		10		3478·001	,,	,,	28744·1
Fe }	3									
Co }	2									
Fe‡	7r	8	M.	5	2	3476·848	3476·831	,,	,,	28753·6*a*
Fe‡	10r	10	M.	7	3	3475·602	3475·594	,,	,,	28763·9*a*
Fe } §	10r	6	} M.	7	3	3466·010	3465·991	,,	8·2	28843·4*a*
Co }	10r	4								
Sr ?	8	3	I.		8		3464·609	,,	,,	28855·1
Co	6r	4	I.		10		3455·384	0·96	,,	28932·1
Fe	8r	8	M. IV.	6	4	3444·024	3444·032	,,	,,	29027·6*a*
Fe	10	10	M. IV.	6	4	3441·135	3441·135	,,	,,	29052·0
Fe	15r	15	M. IV.	7	4	3440·756	3440·759	,,	,,	29055·2*a*
Fe*	6	5	M.	2	1	3427·279	3427·282	,,	8·3	29169·4*a*
?		2	I.		15		3425·721	,,	,,	29182·6
Fe	5	4	II.	1	18	3406·965	3406·955	0·95	,,	29343·4*b*
Fe	2	1	II.	1	18	3406·602	3406·581	,,	,,	29346·6*b*
Ti }	1	3	} II.	1	12	3405·255	3405·272	,,	,,	29357·9*b*
Co }	10r	3								
Fe	2	2	I.	1	12	3389·913	3389·887	,,	8 4	29491·1*b*
Ti }	5	3	} I.		9		3377·667	0·94	,,	29597·8
Ti }	5	3								
Zr	4	1	I.		8		3356·222	,,	8·5	29786·9
Fe	2	2	II.		9		3351 877	,,	,,	29825·5
Fe }	3	3	} II.		9		3348·011	,,	,,	29860·0
Cr }	3	3								

* Red component of double.
† Violet component of double.
‡ Strongest line of a group of six.
§ Iron line measured.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	1/λ –	
Fe	2	2	II.		8		3331·741	0·93	8·5	30005·8
Ti	5	5	I.		10		3318·163	,,	8·6	30128·6
Co-Ti	3, 6	4	I.		10		3308·928	,,	,,	30212·7
Mn	2	1								
Fe*	10	7	M. IV.	1	5	3306·481	3306·471	,,	,,	30235·1*b*
Fe†	10	7	M. IV.	1	5	3306·119	3306 117	,,	,,	30238·4*b*
Fe		3	II.		10		3303·648	,,	,,	30261·0
?		3								
Na	10r	5	M. IV.	1	6	3303·119	3303·107	,,	,,	30265·9*a*
Na	15r	6	M. I.	1	6	3302·504	3302·501	,,	,,	30271·5*b*
Mn-Di	3, 2	4	I.		9		3295·957	0·92	,,	30331·6
Co-Ti	4, 7	5	I.		10		3292·174	,,	,,	30366·5
Fe	5									
Ti	6	5	I.		9		3287·791	,,	8·7	30406·9
Cu	30r	6	M. I.	15	5	3274·090	3274·092	,,	,,	30534·1*a*
Va	10	4	I.		10		3267·839	,,	,,	30592·6
Fe	1	4	II.		10		3260·384	,,	,,	30662·5
Ti	3									
Mn	4									
Cu	40r	9	M. IV.	15	5	3247·671	3247·680	0·91	8·8	30782·5*a*
Fe		6	I.		12		3246·124	,,	,,	30797 2
?										
Ti	10r	8	M.	1	1	3236·696	3236·697	,,	,,	30886·9*b*
Ti	6	4	III.		12		3232·404	,,	,,	30927·9
?	?	5	I.		1		3231·421	,,	,,	30937·3
Ti	5									
Fe	8	8	M.	3	1	3225·907	3225·923	,,	,,	30990·2*a*
Ti	6	4	I.		3		3224·368	,,	,,	31005·2
?	?	7	M. III.	3	1	3222·197	3222·203	,,	,,	31025·9*a*
Fe ?	6	5								
Fe		6	II.		1		3219·909	0·90	,,	31048·0
Fe		6	II.		1		3219·697	,,	,,	31050·0
Ti	4	3	I.		6		3218·390	,,	,,	31062·6
Fe	5	5	M.	1		3214·152		,,	8·9	31103·5
Ti	10r	4	M. I.	1	5	3200·040	3200·032	,,	,,	31240·8*b*
Ni	3	3	M.	1	1	3195·729	3195·702	,,	,,	31283·1*b*
Cr ?	4	4	II.		5		3188·164	,,	,,	31357·1
La ?	1	1	II.		5		3176·104	0·89	9·0	31476·1
Fe ?		5	I.		1		3172·175	,,	,,	31515·1
Mn		1	II.		5		3167·290	,,	,,	31563·7
Ca		8	M.	1	1	3158·994	3158·988	,,	,,	31646·7*b*
Fe		2	II.		3		3153·870	,,	,,	31698·1
Fe		3	II.		5		3140·869	0 88	9·1	31829 2
Co	4	2	II.		3		3137·441	,,	,,	31864·0
Ni	10r	8	M.	1		3134·223		,,	,,	31896·7
Zr	3	1	II.		5		3129·882	,,	,,	31941·0
Va	7	5	I.		9		3121·275	,,	,,	32029·1
Fe		2	I.		3		3115·160	,,	,,	32092·0
Cr ?		3	II.		1		3109·434	,,	9·2	32151·0
.		2	III.		1		3106·677	,,	,,	32180·5
Ni	10r	6	M.	3		3101·994		0·87	,,	32228·1

* Second line from violet side of a group of four.
† Second line from red side of a group of five.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$−	
Ni . .	20r	8	M.	3		3101·673		0·87	9·2	32231·5
Fe . .	6	6	M.	3		3100·779		,,	,,	32240·8
Fe (Mn) .	4?	4	M.	3		3100·415		,,	,,	32244·5
Fe . .	4	7	M.	3		3100·064		,,	,,	32248·2
Fe . .	1	3	II.		9		3095·003	,,	,,	32300·9
? . .		2	II.		9		3094·739	,,	,,	32303·7
Al . .	4	2	M.	8		3092·962		,,	,,	32322·3
Al . .	20r	10	M.	15		3092·824		,,	,,	32323·7
Ti . .	8r	8	M.	1		3088·137		,,	,,	32372·8
? . .		4	I.		1		3086·891	,,	,,	32385·9
Fe . .	6r	7	M.	5		3083·849		,,	9·3	32417·7
Al . .	20r	7	M.	17		3082·272		,,	,,	32434·3
? . .		5	I.		1		3080·863	,,	,,	32449·1
Mn . .	7	2	I.		1		3079·724	,,	,,	32461·1
Ti . .	4	6	M.	3		3078·759		,,	,,	32471·3
Fe ? . .		4	I.		6		3078·148	,,	,,	32477·8
? . .		4	III.		6		3077·303	,,	,,	32486·7
Fe . .		2	M.	1		3077·216		,,	,,	32487·6
Fe . .	10r	10	M.	4		3075·849		,,	,,	32502·0
Ti . .	6	8	M.	3		3075·339		,,	,,	32507·4
Fe . .	10r	10	M.	10		3067·363		,,	,,	32592·0
Co . .	8r	3	M. I.	1	5	3061·932	3061·930	0·86	,,	32649·8*b*
? . .		3	II.		1		3061·098	,,	,,	32658·7
Fe . .	10r	10	M.	15		3059·200		,,	,,	32679·0
Fe . .	10r	10	M.	8		3057·557		,,	,,	32696·6
? . .		5	I.		5		3055·821	,,	,,	32715·1
? . .		3 3 }	II.		1		3053·527	,,	9·4	32739·6
Fe . .		3	II.		5		3053·173	,,	,,	32743·4
? . .		3 3 }	I.		5		3050·212	,,	,,	32775·2
Fe . .	20r	20	M.	13		3047·720		,,	,,	32802·0
? . .			II.	1			3046·778	,,	,,	32812·2
Mn . .	10r	3	II.	5			3044·683	,,	,,	32834·7
Ca . .	15r	4	M. IV.	3	2	3044·114	3044·119	,,	,,	32840·9*a*
Fe . .	15r	15	M.	10	2	3037·505	3037·492	,,	,,	32912·4*a*
? . .		5	III.	7			3035·850	,,	,,	32930·3
Fe . .			M.	1		3027·245		,,	,,	33023·9
Fe . .	10r	10	M.	7		3025·958		,,	,,	33038·0
? . .		4	II.		7		3025·394	,,	,,	33044·1
? . .		5	II.		7		3024·475	,,	9·5	33054·1
Fe . .	7r	7	M.	7		3024·154		,,	,,	33057·6
Fe . .	15r		M.	18		3021·191		0·85	,,	33090·0
Fe . .	25r		M.	18		3020·759		,,	,,	33094·8
Fe . .	10r		M.	15		3020·611		,,	,,	33096·4
Fe . .			M.	1		3019·752		,,	,,	33105·8
Fe . .	5		M.	1		3019·109		,,	,,	33112·9
Fe . .	5		M.	1		3017·747		,,	,,	33127·8
Fe . .		3	M.	1		3016·296		,,	,,	33143·7
? . .		6	IV.	4			3014·274	,,	,,	33166·0
? . .		4	IV.	5			3012·557	,,	,,	33184·9
Fe . .	4r		M.	3		3009·696		,,	,,	33216·4
Ca . .	7r		M.	3		3009·327		,,	,,	33220·5
Fe . .	6r		M.	15		3008·255		,,	,,	33232·4

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$ −	
Fe . .	1		M.	3		3007·408		0·85	9·5	33241·7
Fe . .	2		M.	1		3007·260		„	„	33243·4
Ca . .	15r		M.	3		3006·978		„	„	33246·5
? . .		4	III.	1			3005·404	„	„	33263·9
? . .		3	III.	1			3005·160	„	„	33266·6
Fe . .	8r		M.	15		3001·070		„	„	33312·0
Ca . .	8r		M.	3		3000·976		„	„	33313·0
Ca . .	6r		M.	3		2999·767		„	„	33326·4
Fe . .	4r		M.	5		2999·632		„	„	33327·9
Ca . .	10r		M.	3		2997·430		„	9·6	33352·3
Ca . .	7r		M.	3		2995·074		„	„	33378·6
Fe . .	8r		M.	18		2994·547		„	„	33384·4
Si . .	4		M.	5		2987·766		„	„	33460·2
Fe . .			M.	1		2987·410		„	„	33464·2
Fe . .	10r		M.	15		2983·689		„	„	33506·0
Fe . .	2		M.	6		2981·570		0·84	„	33529·8
Fe . .	12r		M.	15		2973·358		„	„	33622·4
Fe . .	6r		M.	7		2973·254		„	„	33623·6
Fe . .	4r		M.	7		2970·223		„	9·7	33657·8
Fe . .	8r		M.	12		2967·016		„	„	33694·2
Fe . .			M.	1		2966·985		„	„	33694·6
Fe . .	5		M.	3		2965·381		„	„	33712·8
Fe . .	5		M.	3		2957·485		„	„	33802·8
Fe . .	7r		M.	4		2954·058		„	„	33842·0
Fe . .	8r		M.	4		2947·993		„	„	33911·7
Fe . .	10r		M.	4		2937·020		0·83	9·8	34038·3
Fe . .	8r		M.	3		2929·127		„	„	34130·1
Fe . .	7r		M.	3		2912·275		„	9·9	34327·5
Si . .	15		M.	12		2881·695		0·82	10·0	34691·8
Mg . .	100r		M.	15		2852·239		0·81	10·1	35050·1
Fe . .	6		M.	5		2851·904		„	„	35054·2
Fe . .	5		M.	7		2844·085		„	10·2	35150·5
Fe . .	3		M.	1		2843·744		„	„	35154·7
Fe . .	3		M.	1		2838·226		„	„	35223·1
Fe . .	4		M.	7		2832·545		„	„	35293·7
Fe . .	5		M.	1		2825·667		„	„	35379·7
Fe . .	3		M.	1		2823·389		0·80	10·3	35408·1
Fe . .	5		M.	3		2813·388		„	„	35534·0
Mg . .	20r		M.	10		2802·805		„	„	35668·2
Mn . .			M.	3		2801·183		„	„	35688·9
Mn . .			M.	3		2798·369		„	10·4	35724·7
Mg . .	20r		M.	12		2795·632		„	„	35759·7
Mn . .			M.	3		2794·911		„	„	35768·9
Fe . .			M.	3		2788·201		„	„	35855·0
Mg*. .	5r		M.	5		2783·077		0·79	„	35921·1
Fe . .			M.	1		2781·945		„	„	35935·7
Mg*. .	5r		M.	5		2781·521		„	„	35941·2
Mg*. .	8r		M.	5		2779·935		„	„	35961·7
Mg*. .	5r		M.	3		2778·381		„	„	35981·8
Fe . .			M.	2		2778·340		„	„	35982·3
Mg*. .	5r		M.	5		2776·798		„	„	36002·3
Fe . .			M.	2		2772·206		„	10·5	36061·9

* A remarkable symmetrical group of five Mg. lines.

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	$\lambda+$	$\frac{1}{\lambda}-$	
Fe . .			M.	2		2767·630		0·79	10·5	36121·5
Fe . .			M.	2		2762·110		,,	,,	36193·7
Fe . .			M.	2		2761·876		,,	,,	36196·8
Fe . .			M.	3		2756·427		,,	,,	36268·4
Fe . .			M.	2		2755·837		,,	,,	36276·1
Fe . .			M.	3		2750·237		,,	10·6	36349·9
Fe . .			M.	3		2742·485		,,	,,	36452·7
Fe? . .			M.	3		2737·405		0·78	,,	36520·3
Fe? . .			M.	3		2733·673		,,	,,	36570·2
Fe . .			M.	3		2723·668		,,	10·7	36704·5
Ca . .	5		M.	1		2721·762		,,	,,	36730·2
Fe . .			M.	3		2720·989		,,	,,	36740·6
Fe . .			M.	3		2719·119		,,	,,	36765·9
Fe . .			M.	2		2706·684		,,	,,	36934·9
Fe . .			M.	3		2679·148		0·77	10·9	37314·4
Si . .	5		M.	7		2631·392		0·76	11·1	37991·6
Fe . .			M.	3		2631·125		,,	,,	37995·5
Fe . .			M.	2		2611·965		,,	,,	38274·3
Fe . .	r		M.	3		2599·494		0·75	11·2	38457·8
Fe . .			M.	2		2598·460		,,	,,	38473·1
Mn . .			M.	2		2593·810		,,	,,	38542·1
Fe . .			M.	2		2585·963		,,	11·3	38659·0
Fe? . .			M.	2		2584·629		,,	,,	38679·0
Mn . .			M.	2		2576·195		,,	,,	38805·6
Al . .	10		M.	5		2575·198		,,	,,	38820·7
Al . .	10		M.	5		2568·085		,,	11·4	38928·1
Fe . .			M.	2		2549·704		0·74	,,	39208·8
Fe . .			M.	3		2546·068		,,	11·5	39264·8
Fe . .			M.	3		2541·058		,,	,,	39342·2
Hg . .	50r		M.	2		2536·648		,,	,,	39410·6
Fe . .			M.	3		2535·699		,,	,,	39425·4
Si . .	10		M.	5		2528·599		,,	11·6	39536·0*
Fe . .			M.	3		2527·530		,,	,,	39552·7
Si . .	9		M.	10		2524·206		,,	,,	39604·8
Fe . .			M.	3		2522·948		,,	,,	39624·6
Si . .	8		M.	10		2519·297		,,	,,	39682·0
Fe . .			M.	3		2518·188		,,	,,	39699·5
Si . .	15		M.	7		2516·210		0·73	,,	39730·7
Si . .	7		M.	10		2514·417		,,	,,	39759·1
Fe . .			M.	3		2510·934		,,	11·7	39814·1
Si . .	10		M.	15		2506·994		,,	,,	39876·7
Fe . .			M.	3		2501·223		,,	,,	39968·7
Bo . .	20		M.	20		2497·821		,,	,,	40023·2
Bo . .	15		M.	20		2496·867		,,	,,	40038·5
Fe . .			M.	3		2491·244		,,	11·8	40128·8
Fe . .			M.	3		2490·723		,,	,,	40137·2
Fe . .			M.	3		2489·838		,,	,,	40151·5
Fe . .			M.	3		2488·238		,,	,,	40176·3
Fe . .			M.	3		2484·283		,,	,,	40241·3
Fe . .			M.	3		2483·359		,,	,,	40256·2
Fe . .			M.	3		2479·871		,,	,,	40312·9
C . .	10		M.	15		2478·661		,,	,,	40332·6
Fe . .			M.	3		2472·974		,,	11·9	40425·2
Fe . .			M.	3		2462·743		0·72	,,	40593·2

TABLE OF STANDARD WAVE-LENGTHS—*continued.*

Element	Intensity and Character		Kind of Standard	Weight		Wave-lengths		Reduction to Vacuo		Oscillation Frequency in Vacuo
	In Arc	In Sun		In Arc	In Sun	In Arc (a)	In Sun (b)	λ+	$\frac{1}{\lambda}$−	
Fe . .			M.	3		2457·680		0·72	12·0	40676·8
Si . .	3		M.	10		2452·219		,,	,,	40767·4
Fe? . .			M.	3		2447·785		,,	,,	40841·3
Si . .	3		M.	10		2443·460		,,	12·1	40913·5
Si . .	3		M.	10		2438·864		,,	,,	40990·6
Si . .	8		M.	15		2435·247		,,	,,	41051·5
Fe . .			M.	2		2410·604		0·71	12·3	41471·1
Fe . .			M.	2		2406·743		,,	,,	41537·6
Fe . .			M.	2		2404·971		,,	,,	41568·2
Fe . .			M.	2		2399·328		,,	,,	41666·0
Ca . .	25r		M.	5		2398·667		,,	,,	41677·5
Fe? . .			M.	3		2395·715		,,	12·4	41728·8
Fe . .			M.	2		2388·710		,,	,,	41851·2
Fe? . .			M.	3		2382·122		,,	12·5	41966·9
Fe . .			M.	2		2373·771		0·70	,,	42114·6
Al . .	7		M.	3		2373·213		,,	,,	42124·5
Al . .	6		M.	3		2367·144		,,	12·6	42232·4
Fe . .			M.	2		2364·897		,,	,,	42272·5
Fe . .			M.	2		2348·385		,,	12·7	42569·8
Fe . .			M.	2		2343·571		,,	,,	42656·4
Ba . .	20r		M.	1		2335·267		,,	12·8	42808·9
Ba . .	20r		M.	1		2304·364		0·69	13·0	43382·9
Fe? . .			M.	2		2298·246		,,	13·1	43498·3
Ca . .	20r		M.	3		2275·602		0·68	13·3	43931·1
Sr . .	10r		M.	1		2275·376		,,	,,	43935·5
Al . .	4		M.	2		2269·161		,,	,,	44055·8
Al . .	3		M.	2		2263·507		,,	,,	44165·9
Si . .	2		M.	2		2218·146		0·67	13·7	45069·0
Si . .	4		M.	2		2216·760		,,	,,	45097·2
Si . .	2		M.	2		2211·759		,,	13·8	45199·1
Si . .	3		M.	2		2210·939		,,	,,	45215·8
Si . .	2		M.	2		2208·060		,,	,,	45274·8
Sr . .	3		M.	1		2165·990		0·66	14·2	46154·1
Sr . .	2		M.	1		2152·912		,,	14·3	46434·4

EXPLANATORY NOTE.—The first column gives the symbol of the element whose wave-length has been measured, *e.g.* O signifies oxygen, wv water-vapour, &c. If a letter stands at the left within brackets: thus, [A] [C], it is the 'name' of the line in the solar spectrum. A mark of interrogation after the symbol means that it is doubtful if the line is really due to that element. Two symbols on the same line (*e.g.* Mn Di, 3295·957) signify that these two elements have apparently coincident lines as their wave-length. Two or more symbols bracketed (*e.g.* Mn, Si, Fe } 3260·384) mean that the first has a line coinciding with one side of the corresponding solar line, the second with the middle, &c. A mark of interrogation alone signifies that the chemical origin of the line is unknown. The fifth and sixth columns give the 'weights' to be attached to the lines as standards in the arc and solar spectrum respectively. The fourth column gives the character of the standard. M. means a standard in the arc spectrum; I. a remarkably good standard in the solar spectrum; II. a good solar standard; III. an ordinary solar standard; and IV. a rather poor solar standard. Columns 7 and 8 give the wave-lengths in air at about 20° C. and 760 mm. Lines marked with two dashes are double: thus 6″. r signifies reversed.

SODIUM (SPARK SPECTRUM).

Eder and Valenta: 'Denkschr., Wien,' Bd. lxi. 1894.

Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
		$\lambda +$	$\frac{1}{\lambda} -$				$\lambda +$	$\frac{1}{\lambda} -$	
†6161·2	8s	1·68	4·4	16226·2	3284·9	2s	0·92	8·7	30433·6
†6154·6	8s	1·67	,,	16243·6	3280·8	2s	,,	,,	30471·7
*†5896·2	10s	1·61	4·6	16955·5	3212·1	2s	0·90	8·9	31123·4
*†5890·2	10s	1·60	,,	16972·8	3093·1	6s	0·87	9·2	32320·8
†5688·3	6bv	1·55	4·8	17575·1	3078·5	3s	,,	9·3	32474·1
†5682·9	6s	,,	,,	17591·8	3075·9	1n	,,	,,	32501·5
†5675·9	1n	,,	,,	17613·6	3069·5	1n	,,	,,	32569·3
†5670·4	1n	,,	,,	17630·6	3056·4	3s	0·86	,,	32708·9
†5153·7	5s	1·41	5·3	19398·2	3054·2	2s	,,	9·4	32732·4
†5149·2	5s	,,	,,	19415·2	3037·2	1n	,,	,,	32915·7
†4983·5	6s	1·36	5·5	20060·7	2984·3	2s	0·85	9·6	33499·1
†4979·3	6s	,,	,,	20077·6	2980·4	2s	0·84	,,	33542·9
†4752·2	2s	1·30	5·8	21037·1	2975·5	2s	,,	,,	33598·2
†4748·4	2s	,,	,,	21053·9	2951·4	2s	,,	9·7	33872·5
†4669·4	3bv	1·28	5·9	21410·1	2921·4	1n	0·83	9·9	34220·3
†4665·2	3s	,,	,,	21429·4	2919·0	1n	,,	,,	34248·4
4581·7	1	1·26	6·0	21820·0	2906·0	3s	,,	,,	34401·7
4573·6	1	1·25	,,	21858·6	2903·0	1n	0·82	,,	34437·2
4570·4	1	,,	,,	21873·9	*†2852·9	10s	0·81	10·1	35041·9
4565·2	1	,,	,,	21898·9	2841·8	2s	,,	10·2	35178·8
4555·7	1	,,	6·1	21944·4	2809·0	3s	0·80	10·3	35589·6
†4546·0	2s	,,	,,	21991·3	†2680·5	8s	0·77	10·8	37295·7
†4542·8	2s	1·24	,,	22006·8	2672·2	1n	,,	10·9	37411·5
4539·0	1	,,	,,	22025·2	2661·9	1n	,,	,,	37556·3
†4500·0	3n	1·23	,,	22216·1	2612·5	2s	0·76	11·1	38266·4
†4494·3	3n	,,	6·2	22244·2	†2594·0	3s	0·75	11·2	38539·3
†4393·7	1n	1·20	6·3	22753·6	†2543·9	1s	0·74	11·5	39298·2
†4390·7	1n	,,	,,	22769·1	†2512·2	1s	0·73	11·6	39794·2
3533·8	2s	0·98	8·0	28290·2	2502·1	1s	,,	11·7	39954·7
†3303·1	10s	0·93	8·6	30266·0	2493·4	4s	,,	11·8	40094·1
*†3302·5	10s	,,	,,	30271·5	2138·4	1v	0·66	14·4	46749·5

POTASSIUM (SPARK SPECTRUM).

Eder and Valenta: 'Denkschr., Wien.,' Bd. lxi. 1894.

Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
		$\lambda +$	$\frac{1}{\lambda} -$				$\lambda +$	$\frac{1}{\lambda} -$	
*†7699·3	8s	2·08	3·5	12984·7	*†5782·7	3s	1·58	4·9	17288·3
*†7665·6	8s	,,	,,	13041·8	†5359·9	8s	1·46	5·1	18652·0
†6938·8	8s	1·88	3·9	14407·8	*†5343·4	1n	,,	,,	18709·6
†6911·2	7s	1·87	,,	14465·4	†5340·1	8s	,,	,,	18721·1
*†5832·2	3s	1·59	4·7	17141·5	†5323·6	2s	1·45	,,	18779·2
†5812·5	3s	1·58	,,	17199·6	†5112·7	2s	1·40	5·4	19553·7
*†5802·0	4s	,,	,,	17230·7	*†5099·3	2s	1·39	,,	19605·1

* Occurs also in the Flame Spectrum. See Report, 1894.
† Occurs also in the Arc Spectrum. See Report, 1892.

POTASSIUM (SPARK SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
†5084·5	1n	1·39	5·4	19662·2	3716·9	1n	1·03	7·6	26896·5
5057·4	1n	1·38	,,	19767·6	3713·2	1n	,,	,,	26923·3
5006·8	2s	1·37	5·5	19967·3	3682·3	4s	1·02	7·7	27149·2
†4965·5	1n	1·36	,,	20133·5	3670·2	1n	,,	,,	27238·8
†4943·8	1	1·35	5·6	20221·8	3618·4	3s	1·01	7·8	27628·7
4832·3	3s	1·32	5·7	20688·4	3610·4	2	1·00	,,	27690·0
4660·7	3s	1·28	5·9	21450·1	3531·2	2	0·98	8·0	28311·0
4650·7	2s	1·27	,,	21496·2	3481·5	1n	0·97	8·1	28715·2
4609·5	6s	1·26	6·0	21688·3	3476·7	1n	,,	,,	28754·8
4506·1	5s	1·24	6·1	22186·0	*†3447·0	10§	0·96	8·2	29002·5
4467·5	5s	1·22	6·2	22377·7	3440·5	6s	,,	,,	29057·3
4457·2	1n	,,	,,	22429·4	3433·8	1s	,,	,,	29114·1
4424·3	1n	1·21	6·3	22596·1	3421·5	1s	,,	8·3	29218·6
4388·2	3s	1·20	,,	22782·1	3403·8	2s	0·95	,,	29370·6
4309·3	1s	1·18	6·4	23199·2	3385·4	6s	,,	8·4	29530·2
4305·1	2s	,,	6·5	23221·8	3381·4	6s	,,	,,	29565·1
4263·2	6s	1·17	,,	23450·1	3373·0	1	0·94	,,	29638·8
4225·7	6s	1·16	6·6	23658·1	3362·8	1	,,	,,	29728·7
4223·1	6s	,,	,,	23672·7	3345·5	8s	,,	8·5	29882·4
4210·3	1	,,	,,	23744·7	3326·4	1s	0·93	,,	30054·0
4186·3	8s	1·15	6·7	23880·7	3322·0	1s	,,	8·6	30093·7
4149·1	6s	1·14	6·8	24094·8	3312·3	3s	,,	,,	30181·9
4134·7	6s	,,	,,	24178·8	3290·8	3s	0·92	,,	30379·1
4115·1	4s	1·13	,,	24293·9	3224·7	1s	0·91	8·8	31001·8
*†4047·4 }	10s	1·11	7·0	24700·2	3220·9	2s	0·90	,,	31038·4
*†4044·3 }				24719·2	*†3217·5	2§	,,	,,	31071·2
4040·2	1	,,	,,	24744·2	3209·0	1s	,,	8·9	31153·5
4026·0	1	,,	,,	24831·6	3202·1	1s	,,	,,	31220·6
4018·8	1n	,,	,,	24876·0	3190·2	2n	,,	,,	31337·1
4012·3	2	1·10	,,	24916·4	3169·2	1s	0·89	9·0	31544·7
4001·2	6s	,,	7·1	24985·4	3157·5	1s	,,	,,	31661·6
3995·0	1s	,,	,,	25024·2	3143·7	3s	,,	9·1	31800·6
3972·6	3s	1·09	,,	25165·3	3129·3	4s	0·88	,,	31946·9
3966·7	4s	,,	,,	25202·8	3104·5	5n	,,	9·2	32202·1
3955·3	4s	,,	7·2	25275·3	†3102·3	1n	,,	,,	32224·9
3943·3	2s	,,	,,	25352·3	3074·6	1n	0·87	9·3	32515·3
3934·7	1s	1·08	,,	25407·7	3067·3	1n	,,	,,	32592·7
3927·0	1s	,,	,,	25457·5	3062·4	6s	0·86	,,	32644·8
3923·8	1s	,,	,,	25478·3	3056·1	1n	,,	,,	32712·1
3898·1	8s	,,	7·3	25646·2	3051·5	1n	,,	9·4	32761·4
3884·2	1s	1·07	,,	25738·0	3030·0	1n	,,	,,	32993·9
3879·2	1s	,,	,,	25771·2	3023·0	1n	0·85	9·5	33070·2
3874·1	2s	,,	,,	25805·1	†2992·3	4s	,,	9·6	33409·5
3862·3	1s	,,	,,	25884·0	2986·0	1n	,,	,,	33480·0
3818·5	1n	1·06	,,	26181·0	2938·7	1n	0·83	9·8	34018·8
3800·8	1s	1·05	7·4	26302·8	2853·5	1n	0·81	10·1	35034·6
3783·2	3s	,,	,,	26425·2	2833·0	2n	,,	10·2	35288·1
3767·1	1s	1·04	7·5	26538·1	2819·0	1	0·80	10·3	35463·3
3757·4	1s	,,	,,	26606·6	2780·5	1	0·79	10·4	35954·4
3749·1	1s	,,	,,	26665·6	2736·2	1n	0·78	10·6	36536·4
3744·5	1	,,	,,	26698·3	2690·4	1n	0·77	10·8	37158·4
3739·2	1n	,,	,,	26736·2	2662·5	1	,,	10·9	37547·8
3727·5	1n	1·03	7·6	26820·0	2635·3	1	0·76	11·0	37935·3

§ Probably double.

POTASSIUM (SPARK SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ−	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ−	Oscillation Frequency in Vacuo
2614·0	1	0·76	11·1	38244·4	2274·4	1n	0·68	13·3	43954·3
2549·4	2s	0·74	11·4	39213·5	2268·1	1n	„	„	44076·5
2440·9	1	0·72	12·1	40956·4	2261·8	1	„	13·4	44199·2
2379·5	1	0·71	12·5	42013·1	2258·3	1	„	„	44267·7
2358·9	1n	0·70	12·6	42380·0	2254·9	1	„	„	44334·5
2350·4	1n	„	12·7	42533·2	2248·4	1	„	13·5	44462·6
2344·7	1n	„	„	42636·7	2243·5	1	„	„	44559·7
2341·7	1n	„	„	42691·3	2203·9	1	0·67	13·8	45360·3

CADMIUM (SPARK SPECTRUM).

Eder and Valenta: 'Denkschr., Wien.' Bd. lxi. 1894.

No.	Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ−	Oscillation Frequency in Vacuo	No.	Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ−	Oscillation Frequency in Vacuo
	6467·4	2s	1·76	4·2	15458·0		4693·7	2s	1·29	5·9	21299·2
1	6439·3	10s	1·75	„	15525·4	6	†4678·4	10s	1·28	„	21368·9
	6057·7	2s	1·65	4·5	16503·4		†4662·7	3s	„	„	21440·9
	6004·7	2s	1·63	„	16649·1		4646·5	1s	1·27	„	21515·7
	5958·7	2s	1·62	4·6	16777·6		4634·8	1s	„	6·0	21569·9
	5914·1	2s	1·61	„	16904·1		4631·3	1s	„	„	21586·2
	5791·1	2s	1·58	4·7	17263·2		4600·0	1n	1·26	„	21733·1
	5688·2	4s	1·55	4·8	17575·4		4581·9	1s	„	„	21819·0
	5663·6	1s	1·54	„	17651·8		4541·6	1s	1·24	6·1	22012·6
	5640·6	1s	„	„	17723·8		4521·4	1s	„	„	22110·9
	5611·6	1s	1·53	„	17815·4		4491·3	1s	1·23	6·2	22259·1
	5490·2	6s	1·50	5·0	18209·3		4487·8	1s	„	„	22276·4
	5472·5	6s	1·49	„	18268·2		4443·4	2s	1·22	„	22499·1
	5391·1	2s	1·47	5·1	18544·0	7	†4415·9	10s	1·21	6·3	22639·1
2	5379·3	10s	„	„	18584·7		†4413·2	2	„	„	22653·0
3	5338·6	10s	1·46	„	18726·4		4403·5	1	„	„	22702·9
	5308·2	1s	1·45	„	18833·7		4393·5	1	1·20	„	22754·6
	5305·1	3s	„	„	18844·7		4293·9	2s	1·18	„	22752·5
	5203·9	1s	„	5·3	19211·1		4272·9	3s	1·17	6·5	23396·8
	5174·3	3s	1·41	„	19321·0		4271·2	3s	„	„	23406·1
	†5155·2	1s	„	„	19392·6		4245·8	4s	„	6·6	23546·1
4	†5086·1	10s	1·39	5·4	19656·0		4226·6	1n	1·16	„	23653·1
	5026·5	1s	1·37	5·5	19889·1		4217·1	6s	„	„	23706·4
	4854·7	2s	1·33	5·7	20592·9		4214·0	2s	„	„	23723·8
5	†4800·1	10s	1·31	„	20827·2		4191·8	4s	1·15	6·7	23849·4
	4783·6	1s	„	5·8	20899·0		4177·5	2s	„	„	23931·1
	4707·3	2s	1·29	5·9	21237·7		4171·6	2s	„	„	23964·9

† Occurs also in the Arc Spectrum. See Report 1892.

CADMIUM (SPARK SPECTRUM)—*continued.*

No.	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
	4163·9	2s	1·14	6·7	24009·2
	4158·1	5s	,,	,,	24042·7
	4142·1	4s	,,	6·8	24135·5
	4139·8	2s	,,	,,	24149·0
	4136·9	1n	,,	,,	24165·9
	4134·3	1n	,,	,,	24181·1
	4130·9	1n	1·13	,,	24201·0
	4127·1	6s	,,	,,	24223·3
	4116·8	3s	,,	,,	24283·9
	4114·7	5s	,,	,,	24296·3
	4112·8	1	,,	,,	24307·5
	4102·6	1	,,	,,	24368·0
	4095·0	7s	,,	6·9	24413·1
	4092·5	3s	1·12	,,	24428·0
	4083·9	1	,,	,,	24479·5
	4077·4	1	,,	,,	24518·5
	4075·8	1	,,	,,	24528·2
	4072·1	1	,,	,,	24550·5
	4068·8	1	,,	,,	24570·4
	4066·3	1	,,	,,	24585·5
	4064·1	1	,,	,,	24598·8
	4057·7	5s	,,	,,	24637·6
	4054·0	1n	1·11	,,	24660·1
	4049·1	3s	,,	7·0	24689·8
	4044·7	3s	,,	,,	24716·7
	4038·6	1n	,,	,,	24754·1
	4035·1	3s	,,	,,	24775·5
	4029·2	1	,,	,,	24811·8
	4023·3	1	,,	,,	24848·2
	4018·5	2n	,,	,,	24877·9
	4014·8	1n	1·10	,,	24900·8
	4009·2	1n	,,	,,	24935·6
	4006·0	1n	,,	,,	24955·6
	3994·1	3s	,,	7·1	25029·8
	3992·0	4s	,,	,,	25043·0
8a	3988·4	5s	,,	,,	25065·6
8b	3984·7	3s	,,	,,	25088·9
	3977·8	6s	,,	,,	25132·4
	3976·8	6s	,,	,,	25138·7
	3958·9	7s	1·09	,,	25252·4
	3951·0	3s	,,	7·2	25302·8
	3945·7	1	,,	,,	25336·8
	3940·4	8s	,,	,,	25370·9
	3935·7	3s	1·08	,,	25401·2
	3919·6	4s	,,	,,	25505·6
	3910·5	1n	,,	,,	25565·0
	3902·9	1n	,,	7·3	25614·7
	3899·4	2s	,,	,,	25637·7
	3889·8	1	1·07	,,	25701·0
	3865·4	2s	,,	,,	25863·2
	3852·3	4s	1·06	,,	25951·2
	3848·2	2s	,,	,,	25978·9
	3843·8	2s	,,	,,	26008·6

No.	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda+$	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
	3840·6	2s	10·6	7·3	26030·3
	3837·9	2s	,,	,,	26048·6
	3808·2	3s	1·05	7·4	26251·7
	†3614·6	2	1·00	7·8	27657·8
9a	†3613·0	8s	,,	,,	27670·0
9b	†3610·7	10s	,,	,,	27687·7
	3535·8	5s	0·98	8·0	28274·1
	†3501·2	1n	,,	8·1	28553·5
	3499·3	1n	,,	,,	28569·0
10*a*	†3467·8	10s	0·97	8·2	28828·5
10*b*	†3466·3	10s	,,	,,	28841·0
11	†3403·7	10s	0·95	8·3	29371·5
	†3299·1	1	0·92	8·6	30302·7
12*a*	3285·8	4n	,,	8·7	30425·3
12*b*	3283·6	4n	,,	,,	30445·7
	3276·9	3n	,,	,,	30507·9
	3264·2	2n	,,	,,	30626·7
	†3261·2	8s	,,	,,	30654·9
	†3252·6	7s	0·91	8·8	30735·8
	3250·5	7s	,,	,,	30755·7
	3236·4	2n	,,	,,	30889·7
	3221·3	1n	,,	,,	31034·6
	3217·8	3n	0·90	,,	31068·3
	3212·0	1n	,,	8·9	31124·3
	3209·9	3n	,,	,,	31144·7
	3201·8	1n	,,	,,	31223·5
	3197·5	1n	,,	,,	31265·5
	3196·2	1n	,,	,,	31278·2
	3185·4	4n	,,	,,	31384·3
	3182·8	1n	,,	,,	31410·0
	3178·5	1n	0·89	9·0	31452·4
	3176·7	1n	,,	,,	31470·2
	§3173·8	3	,,	,,	31499·0
	3161·6	4n	,,	,,	31620·5
	3157·1	3n	,,	,,	31665·6
	3153·6	1n	,,	,,	31700·8
	3141·2	1n	0·88	9·1	31825·9
13	†3133·3	8s	,,	,,	31906·1
	3129·5	4s	,,	,,	31944·9
	3124·8	3s	,,	,,	31992·9
	3122·2	3s	,,	,,	32019·6
	3119·2	3s	,,	,,	32050·4
	3113·5	2s	,,	9·2	32109·0
	3095·9	5s	0·87	,,	32291·6
	3093·0	1	,,	,,	32321·9
	3089·3	2	,,	,,	32360·6
14*a*	3085·4	5s	,,	,,	32401·5
14*b*	†3081·0	5s	,,	9·3	32447·7
	3077·3	1	,,	,,	32486·7
	3068·9	3	,,	,,	32575·7
	3065·0	4	,,	,,	32617·1
	3059·5	3	0·86	,,	32675·8
	3053·2	3	,,	9·4	32743·1

§ Probably double.

CADMIUM (SPARK SPECTRUM)—*continued.*

No.	Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo	No.	Wave-length	Intensity and Character	Reduction to Vacuum		Oscillation Frequency in Vacuo
			$\lambda +$	$\frac{1}{\lambda} -$					$\lambda +$	$\frac{1}{\lambda} -$	
	3048·9	3	08·6	9·4	32789·3		†2633·1	1n	0·76	11·0	37967·0
	3035 8	1	,,	,,	32930·8		†2629·7	1	,,	11·1	38016·0
	3024·8	1n	,,	9·5	33050·5		2619·1	2	,,	,,	38169·9
	3017·2	3	0·85	,,	33133·8		†2602·0	1n	0·75	11·2	38420·8
	3014·1	1	,,	,,	33167·9		†2592·3	1	,,	,,	38564·6
	3011·4	1n	,,	,,	33197·6		†2580·5	1	,,	11·3	38740·9
	3008·7	1n	,,	,,	33227·4	18	†2573·1	10s	,,	,,	38852·3
	3007·2	1n	,,	,,	33244·0		†2552·2	5	0·74	11·4	39170·5
	3003·8	1n	,,	,,	33281·7		2546·5	1	,,	11·5	39258·1
	2996·2	5n	,,	9·6	33366·0		†2544·9	1	,,	,,	39282·8
	2987·3	2n	,,	,,	33465·4	19	2499·9	3	0·73	11·7	39989·9
15	†2980·8	10s	0·84	,,	33538·4		2495·5	1	,,	,,	40060·4
	2971·8	2	,,	,,	33640·0		2487·9	3	,,	11·8	40182·7
	2964·6	1n	,,	9·7	33721·7		2478·7	2(Cd?)	,,	,,	40331·9
	†2961·8	2bv	,,	,,	33753·5	20	2470·0	4	0·72	11·9	40473·9
	2952·4	2	,,	,,	33861·0		2446·1	2	,,	12·0	40869·4
	2948·9	4	,,	,,	33901·2		2433·8	1	,,	12·1	41075·9
	2926·6	1	0·83	9·8	34159·5		2426·6	1	,,	12·2	41197·7
	†2910·9	4	,,	9·9	34343·7		2423·9	1n	,,	,,	41243·6
	†2893·7	1	0·82	10·0	34547·8	21	2418·9	4	0·71	,,	41328·9
	†2880·9	10b	,,	,,	34701·4		2418·6	1	,,	,,	41334·0
	†2868·4	5b	,,	10·1	34852·5		2411·2	1	,,	12·3	41460·8
	†2862·0	2b	0·81	,,	34930·5		2377·0	2	,,	12·5	42057·3
16	†2837·0	8b	,,	10·2	35238·3		2375·0	1	,,	,,	42092·8
	2834·4	3b	,,	,,	35270·6		2355·4	1	0·70	12·6	42443·0
	2823·9	1	0·80	10·3	35401·7		2350·5	1	,,	12·7	42531·4
	†2818·5	1	,,	,,	35469·6		2343·5	1	,,	,,	42658·5
	2805·5	2	,,	,,	35634·0		2333·2	1	,,	12·8	42846·8
	2802·7	1	,,	,,	35669·6		†2329·4	7s	,,	,,	42916·7
	2795·7	2	,,	10·4	35758·8	22	†2321·2	8s	0·69	12·9	43068·3
	2780·1	1	0·79	,,	35959·5	23	†2313·0	10b	,,	13·0	43220·9
	†2775·1	6s	,,	10·5	36024·2		†2306·7	5s	,,	,,	43339·0
	2773·1	1n	,,	,,	36050·2		†2288·1	10sv	,,	13·2	43691·2
	2767·2	2	,,	,,	36127·1		†2267·5	3s	0·68	13·3	44088·1
	†2764·3	4s	,,	,,	36165·0	24	†2265·1	10sv	,,	,,	44134·9
	†2757·1	1	,,	,,	36259·5		2248·7	1	,,	13·5	44456·6
17	†2748·7	10s	,,	10·6	36370·2		†2239·9	3	,,	,,	44631·3
	†2734·0	3	0·78	,,	36565·8		2228·1	1n	0·67	13·6	44867·7
	2726·9	2	,,	10·7	36661·0		2224·3	3n	,,	13·7	44944·3
	†2712·0		,,	,,	36862·5		2204·0	1nv	,,	13·8	45358·2
	2706·9	2	,,	,,	36931·9	25	†2194·7	5s	,,	13·9	45550·4
	†2677·7	8	0·77	10·9	37334·6		2187·9	1	,,	14·0	45691·9
	†2671·0	2	,,	,,	37428·3		2183·1	1	,,	,,	45792·4
	2668·3	2	,,	,,	37466·1		†2168·8	1n	0·66	14·2	46094·2
	†2660·5	1	,,	,,	37576·0		†2144·5	5sv	,,	14·4	46616·5
	†2639·8	3b	0·76	11·0	37870·0		2111·6	2sv	0·65	14·7	47342·7

Compare Hartley and Adeney's list of Cadmium Spark Lines. Report, 1884

MERCURY (LINE SPECTRUM).

Eder and Valenta: 'Denkschr., Wien,' Bd. lxi. 1894.

The lines given below all occur in the spectrum of a mercury vacuum-tube strongly heated and excited by a powerful condensed spark. Those marked * occur also on a tube on higher pressure (10 mm. to 1,000 mm.) between 180° C. and 1,000° C. with the condensed spark. Those marked † occur in a highly exhausted tube between 15° C. and 80° C., with the spark without condenser. Those marked § occur in the condensed spark between mercury electrodes at atmospheric pressure, and those marked ‖ occur in the arc-spectrum.

** Probably double. ¶ Observed also by Vogel, *Wied. Ann.* v. 500.

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
6363·5	2*§	6360 Huggins	1·73	4·3	15710·3
6152·3	9*§	6151·2 Thalén	1·67	4·4	16249·7
5889·1	8*§	5888·1 „	1·60	4·6	16975·9
5880·5	2		„	„	17000·8
5872·1	8*§	5871·1 „	„	„	17025·1
5864·4	2		„	„	17047·4
5854·5	1b		1·59	„	17076·3
5840·6	1		„	„	17116·9
5834·0	3		„	4·7	17136·2
5819·1	4*§‖	5817 Huggins	„	„	17180·1
5804·3	10*‡‖	5800 „	1·58	„	17223·9
5790·5	2*†§‖	5789·6 Thalén	„	„	17265·0
5781·9	1		„	„	17290·6
5769·5	10*†§‖	5768·1 „	1·57	„	17327·8
5746·6	3		„	„	17396·9
5727·7	5		1·56	„	17454·3
5717·0	1		„	4·8	17486·9
5713·4	2		„	„	17497·9
5699·0	3		1·55	„	17542·1
5695·7	1		„	„	17552·3
5679·1	10*§	5678·1 „	„	„	17603·6
5665·8	3		1·54	„	17645·0
5662·5	3		„	„	17655·2
5637·8	7*		„	„	17732·6
5596·0	8*§	5595·1 „	1·53	4·9	17865·0
5587·9	2		1·52	„	17890·9
5576·2	3		„	„	17928·5
5571·2	8		„	„	17944·6
5553·6	4*b		„	„	18001·4
5541·0	6*		1·51	„	18042·4
5513·4	3b		1·50	„	18132·7
5501·4	2		„	5·0	18172·2
5490·0	3		„	„	18209·9
**5484·6	4		„	„	18227·9
5476·3	4		1·49	„	18255·5
5461·0	10*†§‖b	5460·6 „	„	„	18306·7
5455·0	3		„	„	18326·8
5449·9	3		„	„	18344·0
5443·2	3		„	„	18366·5
5426·5	10*§b	5426·1 „	1·48	„	18423·1
5416·9	3		„	„	18455·7
5398·5	2		1·47	5·1	18518·6
5393·4	2		„	„	18536·1
5384·9	1		„	„	18565·3

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ +	$\frac{1}{\lambda}$ −	
5373·2	3		1.47	5·1	18605·8
5365·5	2*§‖	5364·6 Thalén	,,	,,	18632·5
5360·6	1n		1·46	,,	18649·5
5355·5	1		,,	,,	18667·3
5352·4	1		,,	,,	18678·1
5346·3	3		,,	,,	18699·4
5334·3	2b		,,	,,	18741·5
5311·7	4		1·45	,,	18821·3
5308·0	1		,,	,,	18834·4
5294·7	2		,,	5·2	18881·6
5288·7	6*		1·44	,,	18903·0
5284·2	3		,,	,,	18919·1
5281·5	5		,,	,,	18928·8
5279·3	4*§	5278·6 ,,	,,	,,	18936·7
5275·5	1		,,	,,	18950·3
5273·7	4		,,	,,	18956·8
5254·0	2		,,	,,	19027·9
5242·8	7*		1·43	,,	19068·6
5233·8	4*		,,	,,	19101·4
5218·0	7*§	5217·2 ,,	,,	,,	19159·2
5211·2	4		1·42	,,	19184·2
5207·0	7*§	5206·2 ,,	,,	5·3	19199·6
5196·6	4		,,	,,	19238·0
5190·7	1		,,	,,	19259·9
5187·5	2		,,	,,	19271·8
5172·4	2n		1·41	,,	19328·1
5163·2	4*		,,	,,	19362·5
5149·2	4*		,,	,,	19415·2
5141·5	1		,,	,,	19444·3
5135·6	5		1·40	,,	19466·6
5132·0	7§	5131·2 ,,	,,	,,	19480·3
5113·7	1		,,	5·4	19549·9
5107·3	3		,,	,,	19574·4
5102·9	3 } *		,,	,,	19591·3
5100·5	1 }		1·39	,,	19600·5
5098·4	2		,,	,,	19608·6
5086·3	1		,,	,,	19655·3
5083·0	2		,,	,,	19668·0
5073·6	2		,,	,,	19704·5
5068·2	7*		,,	,,	19725·5
5062·6	4		1·38	,,	19747·3
5058·4	1		,,	,,	19763·7
5051·8	1		,,	,,	19789·5
5048·4	2 } *		,,	,,	19802·9
5045·7	4 }		,,	,,	19813·5
5042·4	2		,,	,,	19826·4
5038·3	2		,,	,,	19842·6
5027·1	1		,,	5·5	19886·7
5020·9	2		1·37	,,	19911·2
5018·4	2		,,	,,	19921·2
5008·6	2b		,,	,,	19960·2
4992·5	5		,,	,,	20024·5
4986·7	3		1·36	,,	20047·8
4981·3	3			,,	20069·6
4974·0	6*			,,	20099·0

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
4970·0	1		1·36	5·5	20115·2
4965·4	1		,,	,,	20133·9
4959·7	4*§‖b	4958·1 Thalén	,,	,,	20157·0
4949·4	3		1·35	,,	20199·0
4943·4	1b		,,	5·6	20223·4
4933·0	2		,,	,,	20266·0
4917·9	2		,,	,,	20328·3
4916·4	4*†§‖	4916·1 ,,	1·34	,,	20334·5
4913·0	2		,,	,,	20348·6
4902·1	4*		,,	,,	20393·8
4898·3	3 } *		,,	,,	20409·6
4895·8	2 }		,,	,,	20420·1
4880·2	1		,,	,,	20485·4
4869·9	3 } *		1·33	,,	20528·7
4867·3	4 }		,,	,,	20539·7
4864·8	3		,,	,,	20550·2
4856·6	3		,,	5·7	20584·8
4849·4	1		,,	,,	20615·4
4844·6	2s		,,	,,	20635·8
4841·3	4*		1·32	,,	20649·9
4826·0	8*§		,,	,,	20715·4
4813·0	4*		,,	,,	20771·4
4797·4	8*		1·31	,,	20838·9
4773·7	1		,,	5·8	20942·3
4768·1	6		,,	,,	20966·9
4753·4	3*		1·30	,,	21031·8
4744·7	6*		,,	,,	21070·3
4740·3	1		,,	,,	21089·9
4729·9	3		1·29	,,	21136·3
4697·9	1		,,	5·9	21280·2
4689·1	1		1·28	,,	21320·1
4687·0	1		,,	,,	21329·7
4681·6	2n		,,	,,	21354·3
4667·5	2		,,	,,	21418·8
4664·2	1		,,	,,	21434·0
4661·0	7*		,,	,,	21448·7
4651·7	5		1·27	,,	21491·6
4647·8	2		,,	,,	21509·7
4639·3	1		,,	,,	21549·1
4637·0	2		,,	,,	21559·8
4635·9	1*		,,	,,	21564·9
4634·2	1		,,	6·0	21572·7
4630·5	1		,,	,,	21589·9
4626·2	2b		,,	,,	21610·0
4620·5	1		,,	,,	21636·7
4616·5	1		1·26	,,	21655·4
4604·8	2		,,	,,	21710·5
4602·9	2		,,	,,	21719·4
4600·7	2		,,	,,	21729·8
4598·2	5*		,,	,,	21741·6
4593·5	1		,,	,,	21763·9
4587·1	2		,,	,,	21794·3
4580·1	1n		1·25	,,	21827·6
4578·2	1		,,	,,	21836·6
4576·9	1		,,	,,	21842·8

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	1/λ −	
4571·5	1		1·25	6·0	21868·6
4568·8	2b		,,	,,	21881·6
4562·3	2 } *		,,	6·1	21912·7
4553·8	6 }		,,	,,	21953·6
4547·0	2		,,	,,	21986·4
4544·2	4		,,	,,	22000·0
4541·7	1		1·24	,,	22012·1
4539·9	1n		,,	,,	22020·8
4537·7	2n		,,	,,	22031·5
4534·9	1		,,	,,	22045·1
4532·7	2		,,	,,	22055·8
4530·3	1		,,	,,	22067·5
4525·1	1		,,	,,	22092·9
4522·9	6*s		,,	,,	22103·6
4518·9	1		,,	,,	22123·2
4516·4	4		,,	,,	22135·4
4511·5	2		,,	,,	22159·5
4507·2	2		,,	,,	22180·6
4505·0	1b		1·23	,,	22191·5
4499·8	1		,,	,,	22217·1
4498·0	1		,,	,,	22226·0
4495·0	1s		,,	6·2	22240·7
4493·2	1s		,,	,,	22249·6
4491·9	1		,,	,,	22256·1
4490·3	3		,,	,,	22264·0
4486·8	8*b		,,	,,	22281·4
4483·7	3		,,	,,	22296·8
4480·7	1		,,	,,	22311·7
4470·5	5*		,,	,,	22362·7
4466·7	2n		1·22	,,	22381·7
4464·2	3		,,	,,	22394·2
4461·5	1		,,	,,	22407·8
4459·3	3		,,	,,	22418·8
4454·1	2n		,,	,,	22445·0
4450·7	1*		,,	,,	22462·2
4446·4	3		,,	,,	22483·9
4435·8	3		,,	,,	22537·6
4434·2	2		,,	,,	22545·8
4431·6	2		,,	6·3	22558·9
4425·9	8b		1·21	,,	22588·0
4422·2	2		,,	,,	22606·9
4420·6	2		,,	,,	22615·1
4416·0	1		,,	,,	22638·6
4415·4	3		,,	,,	22641·7
4414·0	3		,,	,,	22648·9
4412·1	3		,,	,,	22658·6
4408·4	1		,,	,,	22677·7
4401·5	10*b		,,	,,	22713·2
4391·9	10*b		1·20	,,	22762·9
4385·7	8		,,	,,	22795·1
4382·9	8		,,	,,	22809·6
4378·7	8*		,,	,,	22831·5
4376·1	10*		,,	,,	22845·1
4372·6	2†		,,	,,	22863·4
4369·6	1		,,	,,	22879·1

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
4358·6	10*†§‖	4358·0 H. & A., 4358·1 T.	1·20	6·4	22936·7
4347·7	10*†§‖	4348·0 H. & A.	1·19	,,	22994·3
4344·2	2	4341·0 ,,	,,	,,	23012·8
4339·5	6*†§‖		,,	,,	23037·7
4336·9	8		,,	,,	23051·5
4333·4	3		,,	,,	23070·2
4329·1	1		,,	,,	23093·1
4327·2	5		,,	,,	23103·2
4324·7	5		,,	,,	23116·6
4320·4	8		,,	,,	23139·6
4318·3	1		1·18	,,	23150·9
4315·8	1		,,	,,	23164·3
4314·2 }	4		,,	,,	23172·9
4312·9 }	3*		,,	,,	23179·9
4310·3	2		,,	,,	23193·8
4308·6	1		,,	6·5	23202·9
4306·6	4		,,	,,	23213·7
4305·5	4		,,	,,	23219·6
4304·0	1		,,	,,	23227·7
4301·7	2b		,,	,,	23240·1
4300·0	1		,,	,,	23249·3
4297·6	5 } *		,,	,,	23262·3
4292·3	5 }		,,	,,	23291·0
4290·1	3		,,	,,	23303·0
4288·2	2		,,	,,	23313·3
**4285·1	6		,,	,,	23330·2
4282·7	6*		,,	,,	23343·2
4276·7	3b		1·17	,,	23376·0
4270·1	3		,,	,,	23412·1
4264·2	8*b		,,	,,	23444·6
4261·6	8*b		,,	,,	23458·9
4259·0	2		,,	,,	23473·2
4257·6	3		,,	,,	23480·9
4256·4	4		,,	,,	23487·5
4255·2	2		,,	,,	23494·2
4252·7	4		,,	6·6	23507·9
4249·2	2b		,,	,,	23527·2
4248·9	5		,,	,,	23528·9
4237·7	5		1·16	,,	23591·1
4234·5	6*		,,	,,	23608·9
4232·8	4		,,	,,	23618·4
4230·1	7*		,,	,,	23633·5
4227·4	8*		,,	,,	23648·6
4225·4	2		,,	,,	23659·8
4221·6	6*		,,	,,	23681·1
4219·4	1		,,	,,	23693·4
4218·6	2		,,	,,	23697·9
4216·8	10*§b		,,	,,	23708·1
4211·8	6*		,,	,,	23736·2
4206·6	5		,,	,,	23765·6
4200·8	1		1·15	,,	23798·4
4199·1	1		,,	6·7	23807·9
4196·8	6		,,	,,	23821·0
4192·4	5*		,,	,,	23846·0
4186·0	7		,,	,,	23882·4

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum λ+	Reduction to Vacuum 1/λ −	Oscillation Frequency in Vacuo
4183·0	1		1.15	6·7	23899·6
4181·5	1		"	"	23908·2
4178·5	8*		"	"	23925·3
4175·9	6		"	"	23940·2
4169·0	2		1·14	"	23979·9
4167·8	1		"	"	23986·8
4165·7	1		"	"	23998·9
4164·6	1		"	"	24005·2
4162·0	8*		"	"	24020·2
4157·1	4		"	"	24048·5
4155·1	3*		"	"	24060·1
4149·5	3		"	"	24092·6
4148·6	1		"	6·8	24097·7
4145·0	2		"	"	24118·6
4143·7	1		"	"	24126·2
4140·5	7*		"	"	24144·9
4134·9	2*		"	"	24177·6
4132·7	1		"	"	24190·5
4124·3	2		1·13	"	24239·7
4123·0	1		"	"	24247·4
4120·9	8*§b		"	"	24259·7
4117·5	3		"	"	24279·8
4115·3	8*§		"	"	24292·8
4109·1	6*§		"	"	24329·4
4106·9	6*		"	"	24342·5
4104·1	8*		"	"	24359·1
4098·0	3		"	6·9	24395·2
4096·5	1		"	"	24404·2
4093·1	2		1·12	"	24424·5
4091·8	2		"	"	24432·2
4088·4	2		"	"	24452·5
4086·9	1		"	"	24461·5
4084·6	1		"	"	24475·3
4083·1	4		"	"	24484·3
4080·7	1		"	"	24498·7
4078·1	10*†§‖b		"	"	24514·3
4077·0¶	5	4077·5 H. & A.	"	"	24520·9
4073·6	4		"	"	24541·4
4069·8	3		"	"	24564·3
4066·7	2		"	"	24583·1
4062·5	2		"	"	24608·5
4061·8	1		"	"	24612·7
4061·0	4		"	"	24617·6
4057·9	4*†		"	"	24636·4
4056·0	1		"	"	24647·9
4054·5	1		1·11	"	24657·0
4053·5	4		"	"	24663·1
4046·8¶	10*†§‖	4046·5 H & A.	"	7·0	24703·9
4040·7	5*§		"	"	24741·2
4037·5	4		"	"	24760·8
4035·3	5		"	"	24774·3
4033·0	7b		"	"	24788·4
4030·9	1*§		"	"	24801·4
4029·9	3		"	"	24807·5
4024·4	8*§b		"	"	24841·4

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	1/λ−	
4022·0	1		1·11	7·0	24856·2
4021·0	2		,,	,,	24862·4
4020·1	4		,,	,,	24868·0
4014·8	1		1·10	,,	24900·8
4013·7	6b		,,	,,	24907·7
4011·0	2		,,	,,	24924·4
4010·0	1		,,	,,	24930·7
4006·0	8*b		,,	,,	24955·6
4003·5	4		,,	7·1	24971·0
4001·8	3		,,	,,	24981·6
3999·9	1		,,	,,	24993·5
3999·2	2		,,	,,	24997·9
3998·2	1		,,	,,	25004·2
3996·8	1		,,	,,	25012·9
3995·8	1		,,	,,	25019·2
3993·8	6		,,	,,	25031·7
3989·8	2		,,	,,	25056·8
3988·8	1		,,	,,	25063·1
3984·1¶	10*§‖b	3984·0 H. & A.	,,	,,	25092·7
3978·8	4		,,	,,	25126·1
3976·5	6		,,	,,	25140·6
3971·6	1		,,	,,	25171·7
3970·3	1		,,	,,	25179·9
3967·9	8*b		,,	,,	25195·1
3964·9	4*		,,	,,	25214·2
3962·9	5 } *		,,	,,	25226·9
3960·2	5 }		,,	,,	25244·1
3954·7	6		,,	7·2	25279·2
3951·1	2		,,	,,	25302·2
3950·2	3		,,	,,	25308·0
3948·3	7b		,,	,,	25320·2
3945·2	6*		,,	,,	25340·1
3942·3	8*		,,	,,	25358·7
3939·6	3		,,	,,	25376·1
3936·7	5		1·08	,,	25394·8
3931·7	2		,,	,,	25427·1
3930·3	2		,,	,,	25436·1
3928·1	6		,,	,,	25450·4
3925·5	8b		,,	,,	25467·3
3922·0	7		,,	,,	25490·0
3918·9	7		,,	,,	25510·2
3916·4	5		,,	,,	25526·4
3914·5	5*§		,,	,,	25538·8
3911·1	1		,,	,,	25561·1
3909·7	1		,,	,,	25570·2
3908·9	2		,,	7·3	25575·3
3906·6	4*†§‖b		,,	,,	25590·4
3904·4	2		,,	,,	25604·8
3903·7	3		,,	,,	25609·4
3902·1	1*		,,	,,	25619·9
3901·6	1		,,	,,	25623·2
3900·1	5		,,	,,	25633·1
3899·0	4		,,	,,	25640·3
3897·5	1		,,	,,	25650·2
3896·3	1		1·07	,,	25658·1

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3895·6	1		1·07	7·3	25662·7
3887·3	3		,,	,,	25717·5
3883·9	1		,,	,,	25740·0
3882·0	1n		,,	,,	25752·6
3881·1	5		,,	,,	25758·6
3878·0	1		,,	,,	25779·2
3875·2	6*		,,	,,	25797·8
3874·3	1		,,	,,	25803·8
3873·6	2		,,	,,	25808·5
3870·3	1		,,	,,	25830·5
3869·3	3		,,	,,	25837·2
3864·0	1		,,	,,	25872·6
3863·4	1		,,	,,	25876·6
3860·4	2 } *§	3859·0 H. & A.	,,	,,	25896·8
3857·5	3 } *§		,,	,,	25916·2
3856·6	2		1·06	,,	25922·3
3851·2	2		,,	,,	25958·6
3845·1	6*		,,	,,	25999·8
3843·2	4		,,	,,	26012·7
3842·0	1		,,	,,	26020·8
3840·5	2		,,	,,	26031·0
3839·4¶	4*§b		,,	,,	26038·4
**3837·8	2		,,	,,	26049·3
3835·9	1		,,	,,	26062·2
3834·6	3		,,	,,	26071·0
3833·6	1		,,	,,	26077 8
3832·6	2		,,	,,	26084·6
3829·6	2 } *		,,	,,	26105·1
3829·4	2 } *		,,	,,	26106·4
3826·8	5		,,	,,	26124·2
3822·7	2		,,	,,	26152·2
3820·6¶	2*§‖b	3820·0 ,,	,,	,,	26166·6
3817·7	1		,,	7·4	26186·4
3816·3	4		1·05	,,	26196·0
3814·2	1n		,,	,,	26210·4
3812·7	2		,,	,,	26220·7
3811·5	3		,,	,,	26229·0
3811·1	1		,,	,,	26231·7
3810·4	2		,,	,,	26236·6
3809·0	4		,,	,,	26246·2
3807·6	4*§n	3807·0 ,,	,,	,,	26255·9
3803·6	4		,,	,,	26283·5
3801·5	4*§b	3800·0 ,,	,,	,,	26298·0
3797·6	3*b		,,	,,	26325·0
3795·8	3		,,	,,	26337·5
3792·7	1		,,	,,	26359·0
3790·4¶	3*§‖b	3790·0 ,,	,,	,,	26375·0
3788·0	2		,,	,,	26391·8
3787·2	1		,,	,,	26397·3
3786·3	1		,,	,,	26403·6
3784·6	1		,,	,,	26415·5
3783·8	1		,,	,,	26421·1
3782·5	2		,,	,,	26430·1
3780·8	2		,,	,,	26442·0
3779·7	1		,,	,,	26449·7

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}-$	Oscillation Frequency in Vacuo
3776·5	3n		1·04	7·4	26472·1
3774·3¶	8*b		,,	,,	26487·6
3770·7	5*§‖b	3770·0 H. & A.	,,	7·5	26512·8
3762·2	1		,,	,,	26572·7
3759·9	4		,,	,,	26588·9
3757·3	4		,,	,,	26607·4
3756·6	1		,,	,,	26612·3
3755·5¶	1*§n		,,	,,	26620·1
3752·5	2		,,	,,	26641·4
3751·8	3*§‖	3751·0 ,,	,,	,,	26646·4
3750·9	3		,,	,,	26652·8
3747·5	2		,,	,,	26677·0
3743·9	1		,,	,,	26702·6
3742·6	2		,,	,,	26711·9
3741·7	1		,,	,,	26718·3
3740·7	1		,,	,,	26725·5
3738·9	1		,,	,,	26738·3
3735·0	2		1·03	,,	26766·3
3729·5	5		,,	,,	26805·7
3726·9	1		,,	7·6	26824·3
3726·3	1		,,	,,	26828·7
3724·7	1		,,	,,	26840·2
3718·0	1		,,	,,	26888·6
3715·5	3		,,	,,	26906·7
3712·9	1		,,	,,	26925·5
3711·2	1		,,	,,	26937·9
3709·6	3		,,	,,	26949·5
3708·2	3		,,	,,	26959·7
3707·6	1		,,	,,	26964·0
3707·0	2		,,	,,	26968·4
3705·7	3		,,	,,	26977·8
3704·9	1		,,	,,	26983·7
3704·6	1		,,	,,	26985·9
3703·4	6		,,	,,	26994·6
3702·4	3		,,	,,	27001·9
3701·4	1		,,	,,	27009·2
3698·6	2		,,	,,	27029·6
3695·6	1		1·02	,,	27051·6
3691·8	3		,,	,,	27079·5
3690·0	4		,,	,,	27092·7
3689·2	1		,,	,,	27098·5
3688·5	1		,,	,,	27103·7
3685·2	6		,,	,,	27128·0
3680·7	6*§‖b^{r}	3681·9 ,,	,,	7·7	27161·0
3665·4	3		,,	,,	27274·4
3663·3	10*†§‖b	3662·9 ,,	,,	,,	27290·1
3661·4	3		,,	,,	27304·3
3659·4	1		,,	,,	27319·2
3656·4	1		1·01	,,	27341·6
3654·9	8*†§‖	3654·4 ,,	,,	,,	27352·8
3651·9	3		,,	,,	27375·3
3650·3	10*†§‖	3650·0¶	,,	,,	27387·3
3644·5	5		,,	,,	27430·9
3642·5	1		,,	,,	27446·0
3638·5	5		,,	7·8	27476·0

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3633·5	3*		1·01	7·8	27513·9
3632·5	1		,,	,,	27521·4
3630·3	5		,,	,,	27538·1
3627·6	1		,,	,,	27558·6
3623·4	1s		,,	,,	27590·6
3620·0	1		,,	,,	27616·5
3618·6	5§		,,	,,	27627·2
3616·0	2		1·00	,,	27647·1
3613·7	4§		,,	,,	27664·7
3610·7	1		,,	,,	27687·7
3609·1	1		,,	,,	27699·9
3607·6	5§		,,	,,	27711·5
3604·2	2§		,,	,,	27737·6
3594·7	3§		,,	7·9	27810·8
3593·2	3§		,,	,,	27822·4
3590·9	1§		,,	,,	27840·3
3577·7	2§		0·99	,,	27943·0
3561·5	5*†§‖b	3560·1 H. & A.	,,	,,	28070·2
3549·6	1		,,	8·0	28164·2
3543·7	5*†§‖b	3542·3 ,,	,,	,,	28211·1
3533·5	2		0·98	,,	28292·6
3518·0	1		,,	,,	28417·2
3500·1	1		,,	8·1	28562·5
3494·5	1§	3492·6 ,,	0·97	,,	28608·3
3473·6	1§	3473·4 ,,	,,	,,	28780·5
3456·3	1		0·96	8·2	28924·5
3451·8	2§	3451·4 ,,	,,	,,	28962·2
3440·6	1		,,	,,	29056·5
3437·1	1		,,	,,	29086·1
3434·7	1		,,	,,	29106·4
3431·7	2b		,,	8·3	29131·8
3423·5	1		,,	,,	29201·6
3414·9	1		0·95	,,	29275·1
3410·0	1		,,	,,	29317·2
3407·1	1		,,	,,	29342·2
3396·1	1		,,	8·4	29437·1
3390·5	5†§‖b	3389·5 ,,	,,	,,	29485·8
3386·6	1s		,,	,,	29519·7
3366·7	2†§‖n	3365·5 ,,	0·94	,,	29694·3
3351·5	4†§‖	3351·2 ,,	,,	8·5	29828·9
3341·7	6†§‖	3341·2 ,,	,,	,,	29916·4
3320·5	1	3326·4 ,,	0·93	8·6	30107·3
3305·2	1§‖		,,	,,	30246·8
3278·5	2†§		0·92	8·7	30493·1
3264·3	2†§‖		,,	,,	30625·7
3227·5	2§		0·91	8·8	30974·9
3208·7	3†§	3207·1 ,,	0·90	8·9	31156·4
3207·7	1		,,	,,	31166·1
3144·6	3§‖b		0·89	9·1	31791·4
3135·9	1‖n		0·88	,,	31879·7
3131·8	5†§‖	3130·4	,,	,,	31921·4
3125·8	5†§‖	3124·8	,,	,,	31982·7
3116·5	1		,,	,,	32078·2
3107·7	1		,,	9·2	32168·9
3096·0	2§‖	3094·0 H. & A.	0·87	,,	32290·5

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}$−	
3093·3	1		0·87	9·2	32318·7
3090·6	1		,,	,,	32347·0
3085·4	1§‖n		,,	,,	32401·5
3051·0	2§‖		0·86	9·4	32766·7
3038·7	2‖s		,,	,,	32899·4
3027·6	2†‖		,,	,,	33020·1
3023·7	2†‖		,,	9·5	33062·6
3021·6	3†§‖	3021·0 H. & A.	0·85	,,	33085·5
3011·2	1‖n		,,	,,	33199·8
3007·0	2§‖n		,,	,,	33246·2
2972·8	1s		0·84	9·6	33628·7
2967·4	8†§‖	2966·4 ,,	,,	9·7	33689·8
2955·3	1		,,	,,	33827·8
2953 3	1n		,,	,,	33850·7
2947·5	3†§	2946·6 ,,	,,	,,	33917·4
2942·6	1n		0·83	9·8	33973·8
2941·3	1n		,,	,,	33988·8
2939·8	1§		,,	,,	34006·1
2935·8	2§	2935·5 ,,	,,	,,	34052·5
2925·5	7†§‖	2925·2 ,,	,,	,,	34172·4
2916·4	3†§	2915·3 ,,	,,	9·9	34278·9
2915·5	1		,,	,,	34289·5
2893·7	7†§‖	2892·9 ,,	0·82	10·0	34547·8
2886·8	1§		,,	,,	34630·4
2882·2	1†		,,	,,	34685·7
2873·3	2§s		,,	,,	34793·2
2865·1	2§‖b		,,	10·1	34892·7
2857·1	4†§‖		0·81	,,	34990·4
2852·0	1		,,	,,	35053·0
2847·9	8†§‖	2846·8 ,,	,,	10·2	35103·4
2842·0	1n		,,	,,	35176·3
2835·0	1		,,	,,	35263·2
2833·5	2§‖	2832·1 ,,	,,	,,	35281·8
2820·0	4†§‖b	2819·7	0·80	10·3	35450·7
2806·5	1†§	2810·0 H. & A.	,,	,,	35621·3
2804·4	1†§	2804·5 ,,	,,	,,	35647·9
2803·7	3†§‖		,,	,,	35656·9
2799·8	1§	2798·5 ,,	,,	,,	35706·5
2791·2	3§	2790·0 ,,	,,	10·4	35816·5
2789·1	1		,,	,,	35843·5
2784·6	1		,,	,,	35901·4
2781·0	1		0·79	,,	35947·9
2774·7	2§‖	2773·2 ,,	,,	10·5	36029·4
2767·6	1		,,	,,	36121·9
2762·2	2§		,,	,,	36192·5
2759·8	2†§‖	2760·8 ,,	,,	,,	36224·0
2752·9	6†§‖	2751·5	,,	,,	36314·8
2741·3	1n		0·78	10·6	36468·4
2726·5	1§		,,	10·7	36666·4
2724·2	1§		,,	,,	36697·3
2710·4	1§		,,	,,	36884·2
2705·5	1§		,,	,,	36951·0
2702·7	2§	2702·0 H. & A.	,,	10·8	36989·2
2699·5	3†‖		,,	,,	37033·1
2686·7	2§‖b		0·77	,,	37209·6

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum		Oscillation Frequency in Vacuo
			λ+	$\frac{1}{\lambda}-$	
2675·2	1‖		0·77	10·9	37369·5
2672·8	1§‖		„	„	37403·0
2664·5	1		„	„	37519·6
2660·6	1§‖		„	„	37574·6
2658·6	1n	2657·6 H. & A.	„	„	37602·9
2655·3	2†§‖		„	„	37649·6
2653·9	2†§‖		0·76	11·0	37669·4
2652·2	3†§‖	2652·2 „	„	„	37693·5
2648·3	1§‖		„	„	37749·1
2642·7	2§‖b	2644·6 „	„	„	37829·1
2640·5	1†	2640·6 „	„	„	37860·6
2629·0	1n		„	11·1	38026·2
2625·7	1		„	„	38074·0
2614·8	1		„	„	38232·7
2609·7	2§‖		0·75	„	38307·5
2605·3	2§‖		„	11·2	38372·1
2603·1	3†§	2602·3 „	„	„	38404·5
2598·3	1		„	„	38475·5
2584·7	2§	2584·2 „	„	11·3	38677·9
2576·3	3†§‖		„	„	38804·1
2575·2	2§	2575·3 „	„	„	38820·6
2564·1	1†§‖		0·74	11·4	38988·6
2561·4	1		„	„	39029·7
2558·0	1§		„	„	39081·6
2540·4	2§‖		„	11·5	39352·4
2536·7	6†§‖	2535·8	„	„	39409·8
2534·9	3†§‖	2533·8	„	„	39437·8
2524·8	2§‖b	2522·7	„	11·6	39595·5
2515·2	2§	2514·3	0·73	„	39746·7
2507·2	1		„	11·7	39873·4
2505·0	1§‖		„	„	39908·5
2499·4	1		„	„	39997·9
2492·2	3†§s	2491·4	„	11·8	40113·4
2490·2	1§		„	„	40145·6
2483·9	1†§	2484·2	„	„	40247·5
2482·9	1†		„	„	40263·7
2482·1	2†§‖		„	„	40276·7
2478·8	1†§‖n	2477·7	„	„	40330·3
2478·2	1†		„	„	40340·1
2469·5	1§		0·72	11·9	40482·1
2468·1	2§	2468·0 H. & A.	„	„	40505·1
2464·2	4†§‖	2463·7 „	„	„	40569·2
2459·6	1§	2459·3 „	„	12·0	40645·0
2447·0	2†§‖		„	„	40854·4
2414·3	4†§	2414·3	0·71	12·2	41407·7
2412·3	1†§‖		„	12·3	41441·9
2407·6	4†§	2407·3	„	„	41522·8
2399·6	2‖		„	„	41661·3
2390·3	1§	2390·0	„	12·4	41823·3
2380·1	1n		„	12·5	42002·5
2378·4	3†§‖		„	„	42032·6
2374·1	1‖n		„	„	42108·7
2369·3	2§		0·70	„	42194·1
2354·3	1§	2355·2 H. & A.	„	12·7	42462·8
2353·6	1†		„	„	42475·4

MERCURY (LINE SPECTRUM)—*continued.*

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}$−	Oscillation Frequency in Vacuo
2352·6	1†n		0·70	12·7	42493·5
2345·4	2†§‖		,,	,,	42623·9
2341·9	1§	2342·2 H. & A.	,,	,,	42687·7
2340·5	1§	2340·0	,,	12·8	42713·1
2339·3	3§		,,	,,	42735·0
2335·1	1§n		,,	,,	42811·9
2327·5	1n		,,	12·9	42951·7
2323·1	1n		0·69	,,	43033·0
2321·0	1§n		,,	,,	43072·0
2315·0	1§b	2315·2	,,	,,	43183·6
2301·6	1†‖b		,,	13·0	43435·0
2296·4	1§b	2296·5	,,	13·1	43533·3
2292·0	2§n	2292·6	,,	,,	43616·9
2284·0	1		,,	13·2	43769·6
2264·0	2†§b	2264·2	0·68	13·3	44156·3
2262·2	2†§‖	2263·3	,,	13·4	44191·4
2260·4	2†§‖	2261·4	,,	,,	44226·6
2258·6	1n		,,	,,	44261·8
2252·9	2†§‖	2254·0	,,	,,	44373·8
2244·1	1§		,,	13·5	44547·8
2230·0	2§	2231·0	0·67	13·6	44829·4
2224·7	2†§‖b	2225·7	,,	13·7	44936·2
2191·3	1§	2190·9	,,	14·0	45621·0
2150·6	1§	2148·0	0·66	14·3	46484·3

MERCURY (BAND SPECTRUM—SPARK IN VACUUM TUBE WITHOUT LEYDEN JAR).

Eder and Valenta, 'Denkschr. Wien,' Bd. lxi., 1894.

Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}$−	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum λ+	Reduction to Vacuum $\frac{1}{\lambda}$−	Oscillation Frequency in Vacuo
α4517·1	2s	1·24	6·1	22132·0	4477·0	3	1·23	6·2	22330·2
β4514·3	2s	,,	,,	22145·7	4474·6	1	,,	,,	22342·2
4513·0	1 } br, First band	,,	,,	22152·1	4465·5	3	1·22	,,	22387·7
4510·5	2	,,	,,	22164·4	4462·6	1	,,	,,	22402·3
4508·7	2	,,	,,	22173·2	4451·4	2	,,	,,	22458·6
4505·2	2	1·23	,,	22190·5	*4448·8	1	,,	,,	22471·8
*4502·5	2	,,	,,	22203·8	4434·8	1	,,	,,	22542·7
4497·9	2	,,	,,	22226·5	4433·4	1	,,	,,	22549·8
4495·4	1	,,	6·2	22238·8	α 4396·3	3s	1·21	6·3	22740·1
4493·4	1	,,	,,	22248·7	α 4395·0	3s	,,	,,	22746·8
4489·3	3	,,	,,	22269·0	β 4393·2	4s	1·20	,,	22756·1
4487·2	3	,,	,,	22279·4	β 4392·6	3s } br, Second band	,,	,,	22759·3
4484·9	1	,,	,,	22290·8	β 4391·5	2s	,,	,,	22765·0
4478·8	3	,,	,,	22321·2	4390·4	3	,,	,,	22770·7

* Perhaps double.

MERCURY (BAND SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4389·4	3	1·20	6·3	22775·8	4294·8	2	1·18	6·5	23277·5
4388·1	3	,,	,,	22782·6	4292·4	2	,,	,,	23290·5
4386·5	4	,,	,,	22790·9	4291·2	2	,,	,,	23297·0
4385·2	3	,,	,,	22797·7	4289·8	1	,,	,,	23304·6
4384·4	3	,,	,,	22801·8	4282·3	1	,,	,,	23345·4
4382·8	2	,,	,,	22810·2	4278·1	2	1·17	,,	23368·4
4382·0	2	,,	,,	22814·3	4275·3	1	,,	,,	23383·7
4381·3	3	,,	,,	22818·0	4266·5	1	,,	,,	23431·9
4380·0	2	,,	,,	22824·7	4262·9	1	,,	,,	23451·7
4378·3	2	,,	,,	22833·6	4260·6	1	,,	,,	23464·4
4378·0	2	,,	,,	22835·2	4250·7	1	,,	6·6	23518·9
4376·2	2	,,	,,	22844·6	4246·1	1	,,	,,	23544·4
4374·9	1	,,	,,	22851·4	4243·6	1	1·16	,,	23558·3
4374·5	1	,,	,,	22853·4	4233·8	1	,,	,,	23612·8
[4372·6	3, line spectrum]	,,	,,	22863·4	&c., &c.	Numerous very faint lines			
4370·6	2	,,	,,	22873·9					
4369·4	1	,,	,,	22880·1	α {4218·9	3s	,,	,,	23696·3
4369·1	1	,,	,,	22881·7	α {4218·3	3s	,,	,,	23699·6
4368·3	1	,,	6·4	22885·8	4218·0	1	,,	,,	23701·3
4366·1	3	,,	,,	22827·3	4217·6	2 } br Third band	,,	,,	23703·6
4364·0	3	,,	,,	22908·4	4216·8	1	,,	,,	23708·1
[4358·6	10b, line spectrum]	,,	,,	22936·7	4215·9	1	,,	,,	23713·1
					4215·0	1	,,	,,	23718·2
					β {4214·1	4s	,,	,,	23723·3
4353·2	2	1·19	,,	22965·2	β {4213·8	4s	,,	,,	23724·9
4352·6	2	,,	,,	22968·4	4212·9	5	,,	,,	23730·0
4350·0	3	,,	,,	22982·1	4212·1	1	,,	,,	23734·5
[4347·7	10b, line spectrum]	,,	,,	22994·3	*4211·2	4	,,	,,	23739·6
					4210·2	1	,,	,,	23745·2
					4209·1	3	,,	,,	23751·4
4344·0	2	,,	,,	23013·9	4208·7	2	,,	,,	23753·7
4343·1	2	,,	,,	23018·6	4207·6	2	,,	,,	23759·9
4340·6	3	,,	,,	23031·9	4207·2	2	,,	,,	23762·2
[4339·5	10b, line spectrum]	,,	,,	23037·7	4206·7	1	,,	,,	23765·0
					4206·3	3	,,	,,	23767·3
					*4205·5	2	1·15	,,	23771·8
*4338·4	1	,,	,,	23043·6	4204·7	2	,,	,,	23776·3
4336·8	2	,,	,,	23052·1	4203·5	1	,,	,,	23783·1
4332·8	1	,,	,,	23073·4	4202·8	1	,,	,,	23787·1
4332·0	1	,,	,	23077·6	4201·9	2	,,	,,	23792·2
4330·6	2	,,	,,	23085·1	4201·3	2	,,	,,	23795·6
4330·1	2	,,	,,	23087·8	4199·8	1	,,	6·7	23803·9
4328·7	3	,,	,,	23095·2	4198·6	1	,,	,,	23810·8
4326·4	1	,,	,,	23107·5	4197·6	1	,,	,,	23816·4
4321·1	1	,,	,,	23135·9	4197·0	3	,,	,,	23819·8
4319·6	1	,,	,,	23143·9	4195·2	1	,,	,,	23830·1
4318·0	2	1·18	,,	23152·5	4194·4	2	,,	,,	23834·6
4317·6	2	,,	,,	23154·6	4192·8	1	,,	,,	23843·7
4315·2	1	,,	,,	23167·5	4192·3	1	,,	,,	23846·5
4308·3	1	,,	6·5	23204·5	4191·6	2	,,	,,	23850·5
4307·3	1	,,	,,	23209·9	4190·3	1	,,	,,	23857·9
4305·6	3	,,	,,	23219·1	4189·1	2	,,	,,	23864·8
4303·2	1	,,	,,	23232·0	4187·1	4	,,	,,	23876·2

MERCURY (BAND SPECTRUM)—*continued*

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4185·9	2	1·15	6·7	23883·0
4185·1	2	,,	,,	23887·6
4183·6	3	,,	,,	23896·2
4181·3	3	,,	,,	23909·3
4181·0	1	,,	,,	23911·0
4180·2	1	,,	,,	23915·6
4179·7	2	,,	,,	23918·5
4178·8	2	,,	,,	23923·6
4177·2	3	,,	,,	23932·8
4175·0	4	,,	,,	23945·4
4173·9	2	,,	,,	23951·7
4172·5	3	,,	,,	23959·7
4172·0	2	,,	,,	23962·6
4170·0	3	,,	,,	23974·1
4169·1	1	,,	,,	23979·3
4167·8	3	1·14	,,	23986·8
4167·2	1	,,	,,	23990·2
4166·2	2	,,	,,	23996·0
*4164·8	3b	,,	,,	24004·0
4164·1	1	,,	,,	24008·1
4162·1	3	,,	,,	24019·6
4160·0	3	,,	,,	24031·8
4157·9	2	,,	,,	24043·9
4156·7	4	,,	,,	24050·8
4155·0	1	,,	,,	24060·7
4153·9	3	,,	,,	24067·1
4152·0	4	,,	,,	24078·1
4149·0	1	,,	6·8	24095·4
4148·4	3	,,	,,	24098·9
4145·2	1	,,	,,	24117·5
4144·6	1	,,	,,	24121·0
4143·3	4	,,	,,	24128·5
4142·4	1	,,	,,	24133·8
4139·4	4	,,	,,	24151·3
4139·1	3	,,	,,	24153·0
4138·4	1	,,	,,	24157·1
4134·6	3	,,	,,	24179·3
4133·7	3	,,	,,	24184·6
4129·9	2	1·13	,,	24206·9
4129·5	2	,,	,,	24209·2
4128·8	2	,,	,,	24213·3
4124·0	2	,,	,,	24241·5
4123·8	2	,,	,,	24242·7
4123·3	2	,,	,,	24245·6
4121·7	1	,,	,,	24255·0
4119·6	2	,,	,,	24267·4
4118·9	2	,,	,,	24271·5
4117·5	1	,,	,,	24279·8
4113·3	2	,,	,,	24304·6
4112·8	1	,,	,,	24307·5
4109·8	1	,,	,,	24325·3
4109·0	1	,,	,,	24330·0
4108·2	4	,,	,,	24334·8
4105·2	1	,,	,,	24352·5
4101·9	3	,,	,,	24372·1

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4101·6	2	1.13	6·8	24373·9
4100·6	2	,,	,,	24379·9
4097·8	1	,,	6·9	24396·4
4096·7	1	,,	,,	24403·0
4096·2	1	,,	,,	24406·0
4091·8	1	1·12	,,	24432·2
4089·9	3	,,	,,	24443·6
4087·3	2	,,	,,	24459·1
4085·5	2	,,	,,	24469·9
4084·5	2	,,	,,	24475·9
4079·5	1	,,	,,	24505·9
4079·0	2	,,	,,	24508·9
[4078·1	8b, line spectrum]	,,	,,	24514·3
4077·1	3	,,	,,	24520·3
4076·6	2	,,	,,	24523·3
4075·5	1	,,	,,	24530·0
4073·0	2	,,	,,	24545·0
4071·7	2	,,	,,	24552·9
4063·9	2	,,	,,	24600·0
4062·0	1	,,	,,	24611·5
4059·6	1	,,	,,	24626·1
4058·4	2	,,	,,	24633·3
[4057·9	3s, line spectrum]	,,	,,	24636·4
4050·7	1	1·11	7·0	24680·1
4049·8	2	,,	,,	24685·6
4049·0	1	,,	,,	24690·5
4048·1	1	,,	,,	24695·9
4047·6	3	,,	,,	24699·0
[4046·8	10b, line spectrum]	,,	,,	24703·9
4044·5	3	,,	,,	24717·9
4042·0	1	,,	,,	24733·2
4040·6	1	,,	,,	24741·8
4038·7	1	,,	,,	24753·4
4037·1	1	,,	,,	24763·3
4035·1	2	,,	,,	24775·5
4034·6	1	,,	,,	24778·6
4034·2	1	,,	,,	24781·1
4032·8	1	,,	,,	24789·7
4031·6	1	,,	,,	24797·0
4030·8	1	,,	,,	24802·0
4029·8	2	,,	,,	24808·1
4027·8	1	,,	,,	24820·4
4026·8	1	,,	,,	24826·6
4026·2	1	,,	,,	24830·3
4025·4	1	,,	,,	24835·2
4024·2	1	,,	,,	24842·7
4022·2	1	,,	,,	24855·0
4020·4	1	,,	,,	24866·1
4020·2	1	,,	,,	24867·4

MERCURY (BAND SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
4018·8	1	1·11	7·0	24876·0	3970·7	1	1·09	7·1	25177·4
{α4017·5	4	,,	,,	24884·1	3970·1	1	,,	,,	25181·2
{α4017·5	4s} Fourth band	,,	,,		3969·7	3	,,	,,	25183·7
α4017·1	4s	,,	,,	24886·6	3969·1	2	,,	,,	25187·5
*4016·2	2	,,	,,	24892·2	3967·8	3	,,	,,	25195·8
4015·1	3	1·10	,,	24899·0	3965·7	4	,,	,,	25209·1
4014·9	1	,,	,,	24900·2	3965·4	4	,,	,,	25211·0
4013·5	2 b▼	,,	,,	24908·9	3963·8	3	,,	,,	25221·2
4013·2	1	,,	,,	24910·8	3962·8	2	,,	,,	25227·6
β {4012·0	4s	,,	,,	24918·2	3962·0	2	,,	,,	25232·7
β {4011·6	4s	,,	,,	24920·7	3960·9	1	,,	,,	25239·7
4010·8	3}	,,	,,	24925·7	3959·6	4	,,	,,	25248·0
4010·6	3	,,	,,	24926·9	3958·9	3	,,	,,	25252·4
4009·8	3	,,	,,	24931·9	3957·4	3	,,	,,	25262·0
4009·2	1	,,	,,	24935·6	3956·1	1	,,	7·2	25270·2
4008·6	3	,,	,,	24939·4	3955·7	2	,,	,,	25272·8
4008·0	2	,,	,,	24943·1	3953·5	4	,,	,,	25286·8
4007·1	3	,,	,,	24948·7	3952·3	2	,,	,,	25294·5
4006·3	1	,,	,,	24953·7	3950·6	2	,,	,,	25305·4
4006·1	2	,,	,,	24954·9	3949·0	3	,,	,,	25315·7
4005·2	6	,,	,,	24960·5	3946·7	3	,,	,,	25330·4
4004·4	2	,,	,,	24965·5	3945·2	3	,,	,,	25340·1
4003·9	2	,,	,,	24968·6	3943·0	2	,,	,,	25354·2
4003·1	7	,,	7·1	24973·5	3941·1	2	,,	,,	25366·4
4001·8	3	,,	,,	24981·6	3941·0	1	,,	,,	25367·1
4000·9	2	,,	,,	24987·3	3939·6	3	,,	,,	25376·1
4000·4	4	,,	,,	24990·4	3938·5	2	,,	,,	25383·2
3999·7	2	,,	,,	24994·8	3936·7	1	1·08	,,	25394·8
3998·9	2	,,	,,	24999·8	3935·1	2	,,	,,	25405·1
*3997·3	5	,,	,,	25009·8	3934·6	2	,,	,,	25408·3
3996·1	1	,,	,,	25017·3	3932·7	1	,,	,,	25420·6
3995·6	3	,,	,,	25020·4	3931·9	3	,,	,,	25425·8
3994·0	4	,,	,,	25030·5	3929·9	2	,,	,,	25438·7
3993·9	4	,,	,,	25031·1	3926·9	2	,,	,,	25458·2
3991·8	5	,,	,,	25044·3	3923·9	3	,,	,,	25477·6
3990·9	1	,,	,,	25049·9	3921·8	3	,,	,,	25491·3
3990·1	?	,,	,,	25054·9	3918·9	2	,,	,,	25510·2
3989·9	4	,,	,,	25056·2	3918·1	2	,,	,,	25515·4
3987·6	3	,,	,,	25070·6	3917·6	1	,,	,,	25518·6
3987·3	3	,,	,,	25072·5	3915·8	3	,,	,,	55530·4
3986·0	4	,,	,,	25080·7	3914·6	1	,,	,,	25538·2
3985·4	4	,,	,,	25084·5	3913·2	2	,,	,,	25547·3
3983·3	3	,,	,,	25097·7	3910·3	2	,,	,,	25566·3
3982·4	3	,,	,,	25103·4	3908·4	1	,,	7·3	25578·6
3981·5	4	,,	,,	25109·1	3906·7	3	,,	,,	25589·8
3980·6	3	,,	,,	25114·7	[3906·6	5s, line	,,	,,	25590·4
3980·3	3	,,	,,	25116·6		spec-			
3978·4	3	,,	,,	25128·6		trum]			
3976·9	2	,,	,,	25138·1	3904·3	1	,,	,,	25605·5
3976·6	3	,,	,,	25140·0	3902·2	1	,,	,,	25619·3
3975·4	2	1·09	,,	25147·6	3901·5	2	,,	,,	25623·9
3975·0	2	,,	,,	25150·1	3898·5	1	,,	,,	25643·6
3274·2	1	,,	,,	25155·2	3897·7	3	,,	,,	25648·8
3973·1	4	,,	,,	25162·2	3895·0	2	1·07	7·3	25666·6
3971·2	5	,,	,,	25174·2	3894·0	1	,,	,,	25673·6

MERCURY (BAND SPECTRUM)—*continued.*

Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Reduction to Vacuum $\lambda +$	Reduction to Vacuum $\frac{1}{\lambda} -$	Oscillation Frequency in Vacuo
3892·1	2	1·07	7·3	25685·8	3708·4	1	1·03	7·6	26958·2
3888·1	3	,,	,,	25712·2	3706·9	1	,,	,,	26969·1
3887·8	1	,,	,,	25714·2	3706·4	1	,,	,,	26972·8
3885·1	1		,,	25732·1	3706·0	1	,,	,,	26975·7
3882·4	2	,,	,,	25750·0	3705·5	1	,,	,,	26979·3
3878·0	2	,,	,,	25779·2	3703·1	1	,,	,,	26996·8
3876·6	1	,,	,,	25788·5	3702·6	1	,,	,,	27000·4
3875·1	2	,,	,,	25798·5	3700·6	1	,,	,,	27015·0
3872·4	2	,,	,,	25816·5	3699·7	1	,,	,,	27021·6
3870·7	1	,,	,,	25827·8	3698·8	1	,,	,,	27028·2
3867·6	3	,,	,,	25848·5	3697·1	1	1·02	,,	27040·6
3864·7	2	,,	,,	25867·9	3696·1	1	,,	,,	27047·9
3861·7	1	,,	,,	25888·0	3695·3	1	,,	,,	27053·8
3856·6	2	1·06	,,	25922·3	3694·8	1	,,	,,	27057·5
3853·8	1	,,	,,	25941·1	3694·5	1	,,	,,	27059·7
3852·2	1	,,	,,	25951·9	3693·2	1	,,	,,	27069·2
3850·9	1	,,	,,	25960·7	3692·3	1	,,	,,	27075·8
3845·2	1	,,	,,	25999·1	3690·7	1	,,	,,	27087·5
3833·2	1	,,	,,	26080·6	3689·2	1	,,	,,	27098·5
3830·7	1	,,	,,	26097·6	3688·2	1	,,	,,	27105·9
3820·6	1	,,	,,	26166·6	3686·3	1	,,	,,	27119·9
3807·3	1	1·05	7·4	26257·9	3686·1	1	,,	,,	27121·3
&c. &c.	numer-				3684·1	1	,,	,,	27136·1
	ous faint				3681·6	1	,,	7·7	27154·4
	lines				3680·7	1	,,	,,	27161·0
α{3728·6	2s	1·03	7·5	26812·2	3679·8	1	,,	,,	27167·7
3728·0	1s	,,	7·6	26816·4	3676·6	1	,,	,,	27919·3
3726·2	3 } bv Fifth band	,,	,,	26829·4	3676·0	1	,,	,,	27195·8
3725·1	1	,,	,,	26837·3	3675·1	1	,,	,,	27202·4
3723·6	1	,,	,,	26848·1	3671·1	1	,,	,,	27232·1
3722·6	2	,,	,,	26855·3	3670·6	1	,,	,,	27235·8
3722·3	1	,,	,,	26857·5	3669·9	1	,,	,,	27241·0
β3721·4	3	,,	,,	26864·0	&c. &c.	numer-			
3721·1	1	,,	,,	26866·2		ous faint			
*3720·4	1	,,	,,	26871·2		lines			
3719·6	3	,,	,,	26877·0					
3718·3	3	,,	,,	26886·4	α3500·1	1 } bv 6th band	0·98	8·1	28562·5
3717·0	3	,,	,,	26895·8	β3495·0	1	0·97	,,	28604·2
*3715·9	1	,,	,,	26903·8					
3715·2	3	,,	,,	26908·8					
3714·2	1	,,	,,	26916·1	α3274·5	1 } bv 6th band	0·92	8·7	30530·3
3713·2	3	,,	,,	26923·3	β3268·1	1	,,	,,	30590·1
3712·0	2	,,	,,	26932·1					
3711·0	3	,,	,,	26939·3	&c. &c.	numer-			
3709·4	1	,,	,,	26950·9		ous faint			
3708·7	1	,,	,,	26956·0		lines			

OXYGEN COAL-GAS (FLAME SPECTRUM).

Hartley : 'Phil. Trans.' clxxxv. 162 (1894).

Wave-length	Intensity and Character		Previous Measurements	Oscillation Frequency in Vacuo
5659 5627	First edge	Greenish-yellow band	5634·7 Watts 5635·43 K. & R.	17666·7 17770·7
5611 5577	Second edge		5585·3 „ 5585·50 „	17816 17933
5557 5520	Third „		5542·3 „ 5540·86 „	17988·7 18114·3
5492	Fourth „		5503·5 „ 5492·8 Piazzi Smyth	18202
5473	Fifth „		5478·4 „ 5473·0 „ „	18267
5446	Sixth „		5440 „ 5448·8 „ „	18355·5
5422	Seventh „		5425 „ {5434·8 5423·8} „ „	18442
5399	Eighth „			18516
5372	Ninth „			18609
5193	Tenth „			19252·2
5170	First „	Emerald-green band	5165 „ 5165·241 Rowland	19336·2
5138	Second „		5130·4 „ 5129·8 Piazzi Smyth	19457·9
5098	Third „		5100·0 „ 5097·9 Fievez	19608
5086	Fourth „		5082 „ 5086·9 „	19957
4952	Fifth „		4951·50 K. & R.	20186·7
4899	Sixth „		4899·98 „	20409
4816	b			20756·8
4774			4775·32 „	20940·7
4765			4763·86 „	20983·7
4743·5	b	Blue band	4739·8 Watts 4737·18 K. & R.	21075
4732	b		{4732·33 4731·93} „	21124·4
4720	b		4717·2 „ 4715·14 „	21181
4702	b		4698·4 „ {4702·3 4697·5} „	21261
4688	b		4684·2 „ 4688·20 „	21329
4679	b		4677 „ 4678·9 Fievez	21364
4672			4672·2 Fievez	21399
4462				22408
4405		Indigo band		22703
4395				22748
4378	b		E. 4368 L. de B.	22840·9
4364				22910·4
4350				22979
4342	Fine line		4334·4 Piazzi Smyth	23029
4332				23080·0
4312			4313 Watts 4316·7 Piazzi Smyth 4315·0 Eder	23188
4302				23239
4288			4288·3 Piazzi Smyth 4287·6 Eder	23315·7
4282			4281·8 „ „ 4282·0 „	23352·0
			4277·8 „ „ 4276·4 „	
4273			4273·9 „ „	23394
4268			4268·9 „ „ 4269·6 „	23430
4260			4263·1 „ „ 4263·4 „	23466·0
4255			4256·0 „ „ 4256·9 „	23495
4248			4248·1 „ „ 4250·7 „	23540
4240			4241·0 „ „ 4244·3 „	23582·9
4230			4234·0 „ „ 4238·2 „	23642·9
			&c. &c.	

OXYGEN COAL-GAS—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4215		CN 4220 Watts 4216·12 K. & R.	23715
4208		CN 4210 ,, 4197·24 ,,	23766·9
4196		CN 4196 ,, 4180·73 ,,	23829
&c.		&c. &c.	
4003	s		24978
3998	s		25005
3992	s		25045
3984	s		25097·5
3973	s		25169·4
3963	s		25229·1
3954	s		25291
3946	s		25334
3938	s		25384·1
3932	s		25425·3
3926	s		25463·2
3920	s	C 3920·8 Eder and Valenta	25509·0
3913	s		25538
3908	s		25572
3904	s		25606·2
3898	s		25645
3893	b	C 3893·1 Deslandres	25682·1
3882		CN 3883·55 K. & R.	25754·2
3868		,, 3871·54 ,,	25848·2
3856		,, 3855·06 ,,	25924·9
3846			25994·2
3840		,, 3839·95 ,,	26033·1
3831		,, 3831·15 ,,	26093
3825·5		,, 3825·40 ,,	26134·0
3823		,, 3823·90 ,,	26150·5
3818·3	b·	,, 3819·36 ,,	26183·1
3815		,, 3816·24 ,,	26206·8
3790			26379
3642·5		,, 3642·63 ,,	27447
3579·5		,, 3579·22 ,,	27935
3568·5		,, 3568·40 ,,	28014
3563		,, 3563·92 ,,	28059
3544·5		,, 3545·07 ,,	28204
3528		,, 3528·71 ,,	28335
3522		,, 3522·49 ,,	28384·8
3498·5		,, 3497·17 ,,	28576
3487·8		,, 3487·61 ,,	28664·4
3478·8			28738
3473·6			287·0
3452			28961
3448			28993
3445			29014·3
3441			29054
3437			29082
3402			29387
3394			29453·1
3384			29543
3373			29632
3359		3360·1 Deslandres	29763·0
3349			29858
3336·5			29967·0
3330			30027·0
3321			30103·9

OXYGEN COAL-GAS—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3313			30177·9
3304		3305·3 Deslandres	30257·9
3299			30303·9
3288			30402
3278			30492
3269			30586
3256			30708

OXYGEN-CARBONIC OXIDE FLAMES.

Hartley: 'Phil. Trans.' clxxxv. 176 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
6337	2n		15778
6172	2n		16204
5945	2n	5955·6 Piazzi Smyth	16817
5777	1		17313
5534	2s	5540·86 K. & R.	18065
5473	2s	5473 Piazzi Smyth	18266
5168	2s	5165·3 ,, ,,	19347
5037	1b	5079·5 ,, ,,	19852
4970·5	1b		20114
4945	1b		20218
4640	1b		21549·6
4589	1b		21784
4446	1b		22488
4249	1b		23530·9
4224·5	1b		23669
4183	1b		23897·8

LITHIUM.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 177 (1894).

Wave-length	Oscillation Frequency in Vacuo	Wave-length	Oscillation Frequency in Vacuo
6708·2	14902·7	4132·4	24191·6
4602·4	21721·4	3232·8	30923·7

Sodium.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 177 (1894).

Wave-length	Intensity and Character	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Oscillation Frequency in Vacuo
6518	b	15336	{5688·26	8n	{17574·9
6420		15570	{5682·9	8n	{17587·4
6349		15744	{4983·5	6n	{20060·2
6290}		{15894	{4979·3	6n	{20077·2
6271}	b	{15942	{4669·4	4n	{21409·6
6233}		{16038	{4665·2	4n	{21428·9
6138	b	16286	{3303·07	8s	{30265·6
6026	b	16590	{3302·47	8s	{30271·1
{5896·16	10s	{16955·2			
{5890·19	10s	{16972·4			

Potassium.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 178 (1894).

Wave-length	Intensity and Character	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Oscillation Frequency in Vacuo
5832·23	4s	17141·0	4044·29	8s	24718·8
5802·01	6n	17230·3	{3447·49	6s	28997·8
5782·67	6n	17288·0	{3446·49	8s	29006·2
5353·6	4s	18651·6	{3217·76	4s	31068·0
5340·08	4s	18720·7	{3217·27	6s	31072·7
4047·36	6s	24700·1			

A strong continuous spectrum from 4610 to 3440.

Cadmium yields one line only (the least refrangible of the triplets at cadmium 17) 3261·17. Oscillation frequency 30654·4.

Zinc and zinc oxide give nothing but a continuous spectrum.

Calcium Fluoride.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 179 (1894).

Wave-length	Intensity and Character	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Oscillation Frequency in Vacuo
6213·5	b	16090	5352·5}	b	{18678
6009	b	16638	5316}		{18807
5739}	1b	{17420	5316}	b	{18807
5583·5}		{17905	5303·5}		{18850
5583·5}	b	{17905	4231*	4s	23630
5503}		{18166			

* Probably Kayser and Runge's Calcium line 4226·91.

Strontium Oxide.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 179 (1894).

Wave-length	Intensity and Character	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Oscillation Frequency in Vacuo
6085 }	b	{ 16430	4591	sv ?	21774
6053 }		{ 16515	*4228	1	23644
5870 ?	line 2s	17032	4216·5	1	23693
*5547	2n	18023	*4079	1	24510
*4609	4s	21691			

* Kayser and Runge record lines in the arc-spectrum of strontium at 5543·49, 4607·52, 4226·91, and 4077·88.

Barium Oxide.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 180 (1894).

Wave-length	Intensity and Character	Oscillation Frequency in Vacuo	Wave-length	Intensity and Character	Oscillation Frequency in Vacuo
5720 }	2b	{ 17478	5384 }	b^v	{ 18567
5712 }		{ 17503	5356 }		{ 18665
5697 }		{ 17546	5322 }	b^v	{ 18784
5690 }	strong band (overlapping a weak one)	{ 17570	5221 }		{ 19149
5660 }		{ 17662	5162 }	b	{ 19368
5619·5 }		{ 17790	5089·5 }		{ 19642
5587 }	b^v	{ 17895	4932 }	b	20269
5555 }		{ 17997	4887 }		{ 20456
5499 }		{ 18178	4862·5 }		{ 20559
5544 }		{ 18032	4833 }		20684
5503 }		{ 18165	4715 }	b very faint	21202
			4692 }		21306

Magnesium Oxide.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 181 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3929 }	} b^v		25447
3883 }			25752
3874 }			25805
3856 }	4b^v }		25929
3852	4s		25955
3834 }	b^v		26074
3805 }	6b^v		26269
3805 }	1b } b^v		26269
3739 }	2b		26734
3733 }	3b		26781
3714 }	4b	{ Triplet near M and associated bands. } L. & D.	26915
3709 }	5b		26950
3682 }	6b^v		27151
3852	8s	Mg. 2852·22 K. & R.	35050

Calcium Oxide.

Oxyhydrogen (Flame Spectrum)

Hartley: 'Phil. Trans.' clxxxv. 182 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
6253 }	4b^{v}		15988
6116 }			16351
6075 }	2b^{v}		16463
5895 }			16964
5739	4b^{v}		17424
5598 }	8b^{v}	Ca 5594·64 K. & R.	17862
5485 }			18233
5445 }	2b^{v} }		18363
5422 }	}		18440
5390 }	}		18545
5359 }	} b		18660
5341 }	}		18724
5322 }	}		18791
5304 }	2b^{v} }		18852
4222 }	8b^{v}	Ca 4226·91 K. & R.	23681
4215 }			23717

Phosphorus Pentoxide.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 183 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3279	1s		30488
3274	1s		30535
3271	1s		30563
3268	1s		30591
3255	1s		30713
3245	1s		30808

Arsenic.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 183 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3280	2n		30479

Selenium.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 184 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4890 }			20443·9
4816 }	b^v		20757·8
4804 }			20811
4746 }	b^v	4745 Salet	21064·7
4720 }			21180
4676 }	b^v	4675 Plücker & Hittorf	21381
4643 }			21529
4599 }	b^v		21738
4569·5 }			21878·6
4491·5 }	b^v		22258·2
4407·5	b^v		22682
4339	b^v		23042
4299	b^v		23253·0
4222	b^v		23676·9
4170·5	b^v		23969·8
4124	b^v		24242·4
4093	b^v		24426
4041	b^v		24738
3976·5	b^v		25141·1
3941·5	b^v		25364·3
3921·5	b^v		25500·3
3883	b^v		25744·2
3851	b^v		25958
3827	b^v		26122·2
3796	b^v		26335·4
3749	b^v		26664
3733	b^v		26780
3707	b^v		26994

Tellurium.

Oxyhydrogen (Flame Spectrum).

Hartley: 'Phil. Trans.' clxxxv. 185 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4818	2b	4820 Salet	20749
4760	4b	4767	21001
4702·5	b		21258·6
4668·5	b	4670	21414·6
4648	b		21510
4620·5	b		21635
4593	b		21765
4580	b		21829
4532	b		22048·4
4495	b		22240
4470 }	b	4470	22365
4426 }	b^v		22589
4397	b^v	4400	22735
4379	b^v	4378	22831

TELLURIUM—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4335	2bv		23064·1
4325	1bv	4324·6	23206
4211	3bv		23740·9
4201		4200	23802·8
4179 }	} b	4180·7 H. & A.	23923
4163 }		4170·3 H. & A.	24012·8
4151·5	bv		24080·8
4130·5	bv		24202·9
4120		4109·7 H. & A.	24265
4107 }			24340
4098 }	} b		24393·6
4085 }			24471
4072·5	bv	4072·7 H. & A.	24548·7
4025·6 }			24835·5
3999 }	bv		24997·4
3937	bv		25391·3
3880	bv		25768
3769	bv		26526·0
3708·5	bv		26956·9
3661	bv		23710·0
3604	bv		27736
3560	1bv		28083·6
3383·5	4s	3382·4 H. & A.	29547
3281 }	4s	3280·0 ,,	30469·8
3273 }	4s	3273·4 ,,	30541
3248	4s	3246·8 ,,	30781·9

ANTIMONY.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 187 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
5511	bv		18139
4675·5 }			21834
4503 }	bv		22203·4
4399·6	2bv		22740
4273	2bv		23398
4132	2bv		24195·7
4079	2bv		24511
4051	2bv		24676
4038·5	1bv		24754·5
3990	1bv		25056
3949·8	bv		25304
3935·5	bv		25403
3913	bv		25550
3910	bv		25571
3890	bv		25700
3853	bv		25947
3813·5	bv		26215
3778	bv		26462·1
3751·9	bv		26646

ANTIMONY—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3748·5	b^v		26757
3700	b^v		27019
{ 3686·5	1s		27117·9
{ 3676	1s		27195·8
3661	2b^v		27306
3664	2b^v		27434
3626	2b^v		27571
3602	2b^v		27752
3573	2b^v		27981

BISMUTH.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.,' clxxxv. 188 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
5805·5 }	} b^v		17220
5714·2 }	s } b^v		17495
5215·7 }	b^v }		17802·4
5549	1b^v		18005·8
5422	1b^v		18438
5333	1b^v		18745
5310·1	1b^v		18827
5292	1b^v		18890·3
4850·5	1b^v		20609
4724·5	1b^v		21159
4714·5	8b		21205
4707	s		21241
4691	b^v		21309·6
4672·8	b^v		21394
4632	b^v		21584·5
4582	b^v		21820
4544	b^v		22001·4
4516·5	b^v		22135
4484	b^v		22295
4441·5	b^v		22508
4420	b^v		22619
4399	b^v		22727
4382·5	b^v		22811
7373·5 }	1		22859
4353·5 }			22964
4366	b^v		22898·1
4321·2	s		23134
4255·5	b^v		23492
3872·5	b^v		25816·2
3845	b^v		26001
3752	b^v		26646
3652	b^v		27334·8
3527·9	2s		28342
3517·9	2s		28409
3510 5	2s		28467
3067	4s	Water 3067·2 L. & D.	32592

BISMUTH—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3023·8	2s	Bi 3023·8 H. & A.	33061
2992·2	2s	Bi 2992·2 ,,	33376
2983·1	2s	Bi 2982·9 ,,	33431
2937·5	2s	Bi 2937·5 ,,	34021
2900·2	2s	Ag 2901·6 ,,	34473
2897·2	2s	Bi 2897·2 ,,	34501

LEAD.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 190 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
5675	b^v		17616
5620·5	b^v	PbO 5615 Mitscherlich	17786
5585 }			17898·6
5460 }	b	PbO 5460 ,,	18301
5400	b^v		18512·4
5340	b^v	PbO 5328 ,,	18721·4
5241 }			19074
5210 }	b^v	PbO 5220 ,,	19188
5194 }			19247
5140 }	b^v	PbO 5144 ,,	19451·2
5051	b^v		19792
4980·5	b^v	PbO 4993 ,,	20073
4961	2b		20152
4955	2b		20175
4925·5	2b		20296
4914·5	2b	PbO 4913 ,,	20342
4901·5	2b		20396·9
4896	2b	PbO 4880 ,,	20418
4858	2b	PbO 4852 ,,	20579
4824	b^v	PbO 4825 ,,	20722·8
4748	b^v		21054·7
4707	b^v		21237·6
4657	b^v	PbO 4664 ,,	21468
4608	b^v		21696·5
4597·5	b^v	PbO 4593 ,,	21745
4508·5	b^v		22173
4455	s	PbO 4468 ,,	22440
4370·5	b^v	PbO 4381 ,,	22875
4314·5	b^v		23171
4225·5	b^v		23659
4163	b^v		24015
4140·5	b^v		24145·7
4059	6s	Pb { 4062·5 Liveing and 4058·5 Dewar	24631·6
4028	b^v		24819
3985	b^v		25070
3954	b^v		25283
3913	b^v		25547·3
3880	b^v		25766

LEAD—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3839	b^v		26043
3805	b^v		26275
3783	b^v		26431
3740·5	b^v		26727
3715·5	b^v		26906
3684	8s		27138
3671·5	$1b^v$		27229
3655	$1b^v$		27349
3639·5	8s		27469
3610	b^v		27691
3594	b^v		27817
3592·5	b^v		27828·6
3571	b^v		27993·6
3555	b^v		28119
3501·5	b^v		28552
3486	b^v		28677
3447	$2b^v$		29004
3431·5	$2b^v$		29133
3405	b^v		29359
3368	$1b^v$		29686
3352·5	$1b^v$		29820
3345	$1b^v$		29890
3320	$1b^v$		30111
3307	b^v		30226
3304	b^v		30260·9
3264	b^v		30626
3209·5	$2b^v$		31148
(2832·2)	2s		35284

TIN.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxvi. 193 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4668	b^v		21416
4656	b^v		21472
4609	$2b^v$	4600 Salet	21689·5
4557	$2b^v$		21939
4532	$2b^v$		22062
4505·5	$2b^v$		22189
4456	b^v		22543
4454	b^v		22444·3
4369	$2b^v$		22882
4347	$2b^v$		22997·4
4305	b^v		23222
4265	b^v		23439
4243	b^v	4240 Salet	23562·9
4221·5	b^v		23681
4128	b^v		24220
4119	b^v		24271
4089	b^v	4080 Salet	24448·6

TIN—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4033	b▾		24786·5
3981	b▾		25113
3955	b▾		25278
3907	b▾		25588
3871	b▾		25828
3841	b▾		26048
3827	b▾		26125
3810	b▾		26237
3787	2b▾		26416
3761	2b▾		26581
3727	8b▾		26822
3696	8b▾		27046
3618	2b▾		27632
3590	6b▾		27849
3547	2b▾		28182
3490	6b▾		28645
3451	2b▾		28969·3
3421	4b▾		29220
3394	4b▾		29454·1
3329·5	8b▾		30028·0
3298·5	2b▾		30307
3268	6b▾		30593
3234·5	4b▾		30906
3206	5b▾		31181·6
3179	6b▾		31452
3095	4b▾		32301
3068·6	4b▾		32573
3038·8	1b▾		32998
3031	1b▾		33177·0
2989	1b▾		33444

SILVER.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 195 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
5556·7	1s	5556·6 Thalén } (Ångström)	17791·7
5515·0	1s		18127·6
5483·7	1s	5486·6 ,, } (Ångström)	18231
5463·4	1s	5465·66 K. & R.	18298·6
4696·0 }	1st band	4669 L. de B. } (Ångström)	21288
4650·8 }			21496·4
4616·5 }	2nd band	4622 L. de B. } (Ångström)	21657
4591·0 }			21775·6
4563·4 }	3rd band	4570 L. de B. } (Ångström)	21907·3
4533·4 }			22050·7
4519·0 }	4th band	4518 L. de B. } (Ångström)	22123·1
4490·9 }			22262·0
4470·9 }	5th band	4475·1 Thalén } (Ångström)	22361·3
4449·8 }			22467
4424·8 }	6th band		22594
4408·6 }			22677·0

SILVER—*continued.*

Wave length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4396·2 }	7th band	4396 L. de B.	22741
4373·5 }			22859
4360·7 }	8th band		22926
4347·0 }			22998·2
4330·9 }	9th band		23084
4300·5 }			23246·0
4294·7 }	10th band		23278·1
4283·2 }			23341
4273·9 }	11th band		23392
4258·0 }			23478·3
4244·9 }	b		23529
4238·2 }			23588
4231·0 }			23628
4176·4 }	b		23937·5
4156·4 }			24052·7
4147·4 }			24105
4102·0	2s		24372
4091·0	2s		24437·6
4088·0	2s		24455
4030·3	s		24810
3795·4	1s		26340
3775·2	1s		26481
3712·7	1s		26926
3672·0	1s		27224
3631·5	2s		27529·4
3576·5	2s		27952
3539·5	2s	3541·3 H. & A.	28245·4
3518·4 }	2s }		28413·5
3510·0 }	2s		28481·3
3453·0 }	1s		28952·3
3450·7	2s		28971·1
3448·0	3s bv 1st group		28987
3446·7	4s		29005
3445·1 }	5s		29019
3441·1	6s		29052·5
3436·5	7s		29090·4
3432·3 }	8s }		29127
3431·8 }	s }		29131
3421·8	s		29216
3418·5	s		29244·2
3418·1	s		29248
3415·1	s bv 2nd group		29274
3410·5	4s		29313
3407·0	5s		29343·5
3403·2	6s		29375·4
3401·0	7s		29394·9
3397·8 }	8s }		29423·1
3395·0 }	s		29447
3392·5	s }		29469
3389·4	s		29496
3386·2	s		29523·9
3383·5	8s	3383·0 K. & R.	29547
3381·7	s		29563
3378·4	s		29592·2
3374·7	s		29625·1
3371·1	s bv 3rd group		29656
3366·3	s		29698
3362·2 }	s }		29735·1

SILVER—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3359·5	s		29758
3358·2	s		29770
3357·7	s		29775
3354·8	s Third group (of 19 lines)		29809·7
3350·0	3s		29843
3347·2	4s		29877·2
3347·0	5s		29879·0
3341·6	6s		29917·1
3336·4	1n		29964·7
3333·8	1n		29987
3331·7	1n Fourth group (of 6 lines)		30007
3330·4	1n		30019
3328·4	1n		30036 0
3327·4	1n		30043·0
3319·9	b^v		30112
3315·3	b^v		30154
3309·2	b^v		30209·7
3305·5	b^v Group of 9 narrow bands		30243·6
3297·3	b^v		30319·9
3293·5	b^v		30344·9
3289·2	b^v		30393·9
3285·5	b^v		30428
3282·1	b^v		30459
3276·4	8b^v	3280·80 K. & R.	30512
3271·3	2s		30560·5
3269·3	s		30579

IRON.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 199 (1894).

* Double. † Present also in the spectrum of ferric oxide.

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
5927·7		5930·25 K. & R.	16865
5738·5	1b		17421
5689·8			17570
5689·8	b		17570
5619·4	b		17790
5594·3	b		17870
5537·1	b		18055
‖5385	b		18565
5324·8		5324·31 ,,	18775
5266·5		5266·72 ,,	18983·3
4479·3		4479·73 ,,	22319
4459·7		4459·24 ,,	22417
4426·7		4427·44 ,,	22584
4405·7		4404·88 ,,	22692
4384·0		4383·70 ,,	22804
4376·8		R4376·04 ,,	22842
4326·2		R4325·92 ,,	23109
G4308·5		R4307·96 ,,	23204
*4272·4		4271·93 ,,	23400

‖ Due to Manganese. R. A line marked R is one of Rowland's 'normal' lines.

IRON—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4266·9		R4267·97 K. & R.	23430
4071·5		4071·79 ,,	24555
4058·3		4058·30 ,,	24633·6
4052·4		5052·75 ,,	24669·8
4047·5		4045·90 ,,	24700
4031·7		4030·84 ,,	24796
4019·8		Mn	24869·5
4002·9		4005·33 ,,	24975
3996·8		3998·16 ,, / 3997·49 ,,	25013
†3980·6		3981·87 ,,	25115
†3926·6		3928·05 ,,	25458·3
†3921·1		3923·00 ,,	25496
3915·7		R3916·82 ,,	25531
3904·2		3904·00 ,, / 3903·46 ,,	25606
†3900·4		3899·80 ,,	25631·2
3897·8		3898·05 ,,	25648
†3896·5		3895·75 ,,	25657
3894·6		3894·09 ,,	25669
3891·5		3892·02 ,, / 3890·96 ,,	25690·2
†3888·2		3888·63 ,,	25711
3885·1		3886·38 ,, / 3885·61 ,,	25732
3880·2			25765
†3877·6		3878·82 ,,	25782·4
3874·3		3873·88 ,,	25804
†3860·5		3860·03 ,,	25896
†3858·9		3859·49 ,,	25907
3853·7		3854·51 ,,	25941
3845·4		3846·96 ,,	25998
3841·4		3841·19 ,,	26025
3839·1		3840·58 ,,	26040
3835·2		3836·48 ,, / 3834·37 ,,	26067
†3825·9		3826·04 ,,	26130
3821·5		3821·32 ,,	26159
†3821·2			26163
L3819·7		3820·56 ,,	26172·2
3810·6		3810·89 ,,	26235·1
3808·1		3808·86 ,,	26252
3796·1		3795·13 ,,	26335·1
3785·2		3786·07 ,,	26410·9
3772·6		3773·84 ,,	26497·3
3765·3		3767·30 ,,	26548
3763·3		3763·90 ,,	26565
†3757·9		3758·36 ,,	26599
3751·9		3751·97 ,,	26645·0
3749·4		3749·61 ,,	26668
3748·1		3748·39 ,,	26672
3747·6		R3747·09 ,,	26676
3743·5		3745·67 ,, / 3743·45 ,,	26705·0
†3736·9		3737·27 ,,	26748
3735·5		3735·00 ,,	26763
M3728·2		3727·78 ,,	26815
3727·9		3727·13 ,,	26817

IRON—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
3722·3		3722·69 K. & R.	26857
†3720·2		3720·07 „	26872
3705·5		3705·70 „	26969
3688·5		3687·77 „	27095
3685·8		3687·58 „	27134
3681·6		3680·43 „	27154
3648·6		3647·99 „	27399
3631·0		3631·62 „	27542
3609·2		3608·99 „	27692
N†3581·1		3581·32 „	27909
3569·6		3570·23 „	27997
3565·0		3565·50 „	28020
3531·2			28320
3501·8		3500·64 „	28559
†3492·3		3490·65 „	28622
3475·5		{ 3476·75 „ 3475·52 „	28752
3460·9		3460·02 „	28827
O3440·8		3441·07 „	29045
†3400·2		3440·69 „	29060
3059·1		3059·19 „	32680
S3047·4		3047·71 „	32806
3039·1		3040·54 „	32896
T†3021·1		{ 3021·15 „ 3020·70 „	33091

NICKEL.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 203 (1894).

* Also in the spectrum of the flame of nickel tetra-carbonyl.

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
*3859		3857·8 L. & D.	25893
*3809		3806·6 „	26248
*3784		3783·0 „	26419
*3776		3775·0 „	26478
*3619		3618·8 „	27620
*3611		3609·8 „	27687
3599		3597 „	27777
*3574		3572 Cornu	27972
*3569		3570·8 „	28012
3527		3527·1 L. &. D.	28339
3518		3519·1 „	28417
3513		3514·4 „	28459
3503		3501·8 „	28539
3496		3492·3 „	28599
3487		3485·2 „	28667
3475		3470·8 „	28769
3462		3461·1 „	28870
*3460		3457·9 „	28892
3453		3452·9 „	28954
*3445		3445·7 „	29017

NICKEL—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
*3436		3437·7 L. & D.	29097
*3433		3433·0 „	29123
*3423		3423·1 „	29205
*3415		3413·8 „	29276
*3392		3392·4 „	29469
*3391		3390·4 „	29484
*3381		3380·0 „	29565
*3370		{ *3371·3 „ 3368·9 „	29665
*3316		3315·1 „	30148
*3233		3232·6 „	30925

COBALT.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 204 (1894).

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
4119		4120 Huggins	24270
3996		3397·3 L. & D.	25019
3899		3905·2 „	25633
3875		3873·2 „	25797
3847·5		3844·8 „	25983
3819·5			27620
3612		3611·3 „	27680
3603		3601·6 „	27747
3596		3594·4 „	27797
3578		3574·9 „	27942
3571		3568·9 „	27992
3536		3532·8 „	28272
3531		3529·3 „	28312
3529		3528·4 „	28327
3527			28344
3517		3517·7 „	28429
3513		3512·0 „	28459
3509·5		{ 3509·7 „ 3509·3 „	28487
3504		3502·0 „	28529
3496		3495·1 „	28599
3483		3482·7 „	28702
3468		3465·2 „	28827
3463		3462·2 „	28870
3461		3460·6 „	28887
3454		3452·9 „	28945
3449		{ 3448·9 „ 3448·6 „	28987
3443		3443 0 „	29037
3432		{ 3432·9 „ 3432·4 „	29129
3415		3414·2 „	29277
3413		{ 3412·0 „ 3411·7 „	29292
3409		3408·6 „	29328
3405		3404·5 „	29357

Chromium.

Oxyhydrogen (Flame Spectrum).

Hartley: ‘Phil. Trans.’ clxxxv. 205 (1894).

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Rowland)	Oscillation Frequency in Vacuo
4290 }	s	4289·87 Hasselberg	2330
4277 }	s	4274·91 ,,	2337
4255 }	s	4254·49 ,,	2349
3607 }	s	3605·46 ,,	27716
3595 }	s	3593·57 ,,	27802
3580 }	s	3578·81 ,,	27927

Aluminium.

Oxyhydrogen (Flame Spectrum).

Hartley: ‘Phil. Trans.’ clxxxv. 207 (1894).

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
4042	s		24733
3968·3	s		25193
3953·5	s		25287

Copper.

Oxyhydrogen (Flame Spectrum).

Hartley: ‘Phil. Trans.’ clxxxv. 207 (1894).

Wave-length	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
5506·5	b		18155
5080	2s		19679
3290	b	3289·9 H. & A.	30389
3262·5	b	{ 3265·2 ,, { 3260·2 ,,	30643

Copper Oxide.

Oxyhydrogen (Flame Spectrum).

Hartley: ‘Phil. Trans.’ clxxxv. 208 (1894).

Wave-length	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
5840	1n		17120
5790	2n		17267
5747	4b^{v}		17397
5577 }	5b	5563 L. de B.	17934
5356 }		5355 ,,	18667
5296	b^{v}	5300 ,,	18875
5241	b^{v}	5239 ,,	19077
5183	b^{v}	5150 ,,	19293·2

COPPER OXIDE—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Angström)	Oscillation Frequency in Vacuo
5107	b^v	5106 L de B.	19582
4957	b^v	4945 „	20167
4849	b^v	4847 „	20616
4777	b^v	4757 „	20926
4712	b^v	4704 „	21219·7
4688	b^v		21324
4644	b^v	4659 „	21525·6
4518	b^v	4522 „	22128
4456	b^v	4436 „	22438
4379	b^v	4353 „	22833
4328	b^v	4331 „	23099
4280	b^v	4281 „	23355·0
4228	b^v	4217 „	23643
4096	1s		24405
4080	1s		24507·6
4069	1s		24569
4053	1s		24664
4040	1s		24743
4031	1s		24802
4017	1s		24888
3282	4b		30452·8
3256	4b		30697

MANGANESE.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley: 'Phil. Trans.' clxxxv. 1029 (1895).

* Seen also in the spectrum of manganese oxide.

Wave-length	Intensity and Character	Previous Measurements (Rowland)	Oscillation Frequency in Vacuo
*5855	$2b^v$	Fe 5856·24 Kayser & Runge	17073
5813	s		17197
5800	s	Fe 5800·21 „ „	17237
5764	$1b^v$		17345
5730	$1b^v$		17446
5712	$1b^v$ very weak		17503
5692	b^v		17563
*5622	b^v	Fe 5624·70 „ „	17781
5598	3b		17858
*5591	b^v	Fe 5592·6 „ „	17881
*5571	s	Fe 5573·05 „ „	17945
5556	b^v		17995
5532	s		18072
5500	s		18175
*5478	s	Fe 5476·82 „ „	18250
5465	b^v		18293
*5445	s	Fe 5447·05 „ „	18360
*5438	s		18385
*5402	$4b^v$		18505
*5391	b	Fe 5393·30 „ „	18543

MANGANESE—*continued.*

Wave length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
*5370·5	4b^v	Fe 5371·62 Kayser & Runge	18615
5364	s		18637
*5347	b^v weak		18698
*5315	„	Fe 5316·85 „ „	18810
*5270	b^v	Fe 5270·04 „ „	18968
*5235	b^v	Fe 5233·05 „ „	19095
*5199	b^v	Fe 5198·82 „ „	19230
*5166	b^v	Fe 5167·50 „ „	
*4830	s	Fe 4832·84 „ „	20696
*4791·5	s		20864
*4762	s	Mn 4762·2 Thalén	20992
*4064	s	Mn 4063·6 Thalén, Fe 4063·63 K. & R.	24598
*4056	s	Mn 4055·5 Thalén	24649
*4049·5		Mn 4049·0 Thalén	24687
*4041·3		Mn 4041·6 Thalén	24735
*4036·5	s } 8b^v	Mn 4035·6 Cornu; Fe { 4035·76 K. & R., 4033·16 „, 4030·84 „ }	24766
*4029·5	n	Mn 4030·6 „	24810
*3894 ?	s	Fe 3895·75 K. & R.	25676
*3874	s		25808
*3860	s	Fe 3860·03 „	25898
*3847	s		25985
*3835	s	Fe 3834·37 „	26070
3827	s		26125
*3824	s	Fe 3824·58 „	26143
*3808	s	Fe 3805·47 „	26255
*3803	1s		26289
3764	2s		
*3621	1s	Fe 3621·61 „	27607
*3612			27677
*3607·5		Fe 3608·99 „	27712
*3604	s		27737
*3600	4s		27792
*3589	s		27852
*3587	s		27870
*3578	2s		27937
*3576	s		27954
*3571	s		28000
*3568	s	Fe 3570·23	28020
*3566	s weak	Fe	28037
*3562	s doubtful		28067
*3549	s „		28167
*3543	s „		28217
*3536	s „		28274
*3534	s „		28288
*3533	s „		28299
*3530·5	s „		28317
*3529·5	s „		28322
3528	s „		28342
*3525	s „		28358
*3524	s „		28367
3515·5	s „		28437
3514·5	s „		28447
*3513	s „		28454
*3511	s „		28475

MANGANESE—*continued.*

Wave-length	Intensity and Character	Previous Measurements	Oscillation Frequency in Vacuo
*3507	s doubtful		28504
*3503	s "	Fe 3500·64 K. & R.	28537
*3498	s "		28577
*3497	s "	Fe 3497·92 "	28587
*3493·5	s "		28617
*3485	s "		28685
*3476	s "	Fe 3476·75 "	28762
*3473·5	s "		28782
*3472	s "		28792
*3470·5	s "	Fe 3471·40 "	28806
*3468	s "	Fe 3468·92 "	28824
*3467	s "		28834
*3465	s "	Fe 3465·95 "	28852
*3464·5	s "		28885
*3461	s "	Fe 3460·02 "	28884
*3457	s "	Fe 3458·39 "	28921
*3453	s "	Fe 3453·10 "	28954
*3448	s "		28999
*3442	s "	Fe 3441·07 "	29047
*3437 }	b^v		29085
*3434 }			29110
*3431	b^v		29140
*3419	b^v		29237
*3418	b^v		29250
*3415	b^v	Fe 3417·92 "	29272
*3413	b^v		29290
*3410	b^v		29318
3406	b^v		29354

MANGANESE OXIDE.

OXYHYDROGEN (FLAME SPECTRUM).

Hartley : 'Phil. Trans.' clxxxv. 1033 (1895).

* Seen also in the spectrum of the metal manganese.
† Bands peculiar to the *oxide* of manganese

Wave-length (Rowland)	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
δ { 5873	b^v		
δ { *5856	b^v	5858 Lecoq de Boisbaudran	17023
		Fe 5856·2 K. & R. (Rowland)	17071
α { 5827	b		17155
α { 5800	2b^v	{ 5807 L. de B.	
		{ Fe 5800·21 K. & R. (Rowland)	17235
α { 5752	3b^v	5759 L. de B.	17380
α { 5717	3b^v	5719 "	17485
α { 5681	3b^v	5683 "	17598
α { 5645	b^v indistinct	5644 Watts	17700
α { *5622	s	Fe 5624·70 K. & R. (Rowland)	17782
α { 5607	b^v	5607 Watts	17830
α { *5591	b^v	Fe 5591	17880
α { 5586	b^v	5587 L. de B.	17897

MANGANESE OXIDE—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Ångström)	Oscillation Frequency in Vacuo
*5575	2b^{v}	Fe 5573·05 K. & R. (Rowland).	17932
*5474		5473 L. de B.	
*5443·5	n	Mn 5543·1 Thalén	18365
*5438	n		18383
a 5432	b^{v}	5433 Watts, 5432 Huggins	18404
5427	b^{v}	5427 L. de B.	18420
*5405	4s	Mn 5406·6 Thalén	18495
*5400	4b^{v}	Mn 5399·9 Thalén, 5398 L. de B.	18513
*5368·5	b^{v}	5367 L. de B.	18622
*5347	1b^{v}	Mn 5348 Huggins	18697
*5318	1b^{v}	Fe 5316·85 K. & R. (Rowland).	18795
*5271	2b^{v}	(E_1) Fe 5270·43 K. & R. (Rowland)	18965
*5234	3b^{v}	Mn. 5233·8 Thalén, (E_2) Fe 5269·65 K. & R. (Rowland).	19100
*5197	4b^{v}	Fe 5198·82 K. & R.	19236
*5163	2b^{v}		19362
5055	2b^{v}		19775
5018	2b^{v}		19922
4976	2b^{v}		20090
4935	s		20257
4896	Edge of band	doubtful	20417
4853	Edge of band		20599
*4828	n	Fe 4832·84 K. & R. (Rowland).	20704
*4790	n		20869
4776·5	1b		20929
4770			20959
*4762	s	Mn 4761·3 Thalén	20992
4749·5	2b^{v}		21049
4696	1b^{v}		21287
4656 †	1b^{v}		21470
4600	Doubtful		21734
4575	4s		21851
4491 †	1b^{v}.	Mn 4491·1 Thalén	22261
4457		Mn 4457·6 „	22430
4403	b^{v}		22707
4293 †	b^{v}		23287
4273	b^{v}	Mn 4271·6 Thalén	23394
4252			23513
&c. &c.	Imperfect edges	as far as 4226	
4226		Mn 4227·0 Thalén	23657
4135	b^{v}		24173
4133 †	b^{v}	Fe 4132·15 K. & R. (Rowland).	24189
4130	b^{v}		24208
4125·5	b^{v}		24231
4121	3n		24257
4079	4n	Mn 4079·6 Ångström	24507
4075	2n		24531
4065	1n		24593
*4062	1n	Fe 4063·63 K. & R. (Rowland).	24610
*4054·5	4s	Mn 4054·3 Thalén	24657
*4049†	4s	Mn 4048·7 Cornu	24692
*4040†	4s	Mn 4040·6 „	24743
*4037	4b^{v}		24763
*4025 †	4b^{v} strong		24838
3994	4s		25029

MANGANESE OXIDE—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Rowland)	Oscillation Frequency in Vacuo
3991	4s	Mn 3991·7 Lockyer (Ångström).	25048
3988	2s	Mn 3989·2 ,,	25070
*3894	4s	Fe 3895·75 K. & R.	25675
3886	1s	Fe 3886·38 ,,	25728
3882	1s		25753
3878	1s	Fe 3878·82 ,,	25778
*3873	4s		25810
3869	1s		25837
3866	1s		25858
*3860	1s	Fe 3860·3 ,,	25900
*3846	2s		25993
3842	2s	Fe 3841·19 ,,	26023
*3833·5	5s	Fe 3834·37 ,,	26078
*3824	6s	Fe 3824·58 ,,	26144
*3809	1s		26243
*3806·5	1s	3806·4 Cornu (Ångström).	26263
3752 } †	2b		26645
3728 } †		Fe 3727·78 K. & R.	26816
3721 } †			26867
3715 } †			26907
3670 } †	2b		27242
3661 } †			27306
3623 } †	2b		27596
*3621 } †		Fe 3621·61 ,,	27607
*3612	2n		27677
*3609	2n	Fe 3608·99 ,,	27700
*3603	2s	Fe 3605·62 ,,	27745
*3600	2s		27800
*3588	1s		27862
*3587	1s		27872
*3578	2s		27940
*3576	3s		27957
*3570	4s	Fe 3570·23 ,,	28005
*3564	1b[v]	Fe 3565·50 ,,	28049
*3561·5 }	1b		28072
*3559·5 }			28086
3553	1b[v]		28135
*3548	4s		28175
*3541·5	1n		28228
*3539	1n		28246
*3533	1s		28297
*3532	2s		28305
3530	3s		28322
*3528·5	1s		28331
*3526	4s	Fe 3526·51 ,,	28350
*3524	2s		28366
3523	2s		28375
3521	2s		28392
3520	2s		28400
3518	1s		28417
3513·5	3s		28452
*3513	2s		28459
*3510	2s double		28479
*3506	4s		28512
*3502	8s	Fe 3500·64 ,,	28544

MANGANESE OXIDE—*continued.*

Wave-length	Intensity and Character	Previous Measurements (Rowland)	Oscillation Frequency in Vacuo
*3498	1n		28582
*3496·5	1n	Fe 3497·92 K. & R.	28592
3494	1n		28614
3492·5	1n		28624
3490·5	1n	Fe 3490·65 ,,	28642
3488·5	1n		28657
3487	1n		28670
*3485	1n		28686
3484	1n		28695
3482·5	1n		28707
3481	1n		28722
3478·5	1n		28741
3477	1n	Fe 3476·75 ,,	28754
*3475 }	4s	Fe 3475·52 ,,	28766
*3474 }			28779
*3471	2s		28799
*3470	2s	Fe 3471·40 ,,	28812
*3468	4s	Fe 3468·92 ,,	28830
*3466	1s		28841
*3465	2s	Fe 3465·95 ,,	28852
*3463·5	2s		28864
*3462	1s	Fe 3460·02 ,,	28875
3460·5	2s		28889
*3456	8s	Fe 3458·39 ,,	28927
*3451	1s	Fe 3453·10 ,,	28970
*3449			28986
3447	b▾		29005
3445	2b▾		29020
3444	2s		29030
*3441	2s	Fe 3441·07 ,,	29051
3439	2s		29070
*3437 }	n		29088
*3433·5 }			29117
*3430	b▾		29148
*3417·5	1s		29252
*3415	s	Fe 3415·61 ,,	29277
*3413	8s		29294
*3410	1s		29315
3409	1s		29324
3405	8s		29360
3406	8s		29402
3395	8s		29446
3391	8s		29484
3388	8s		29508

NOTE.—Unless otherwise stated, all wave-lengths are upon Rowland's scale in air at about 20° C. and 760 mm. pressure. All oscillation frequencies are in vacuo.

The Production of Haloids from Pure Materials.—Report of a Committee, consisting of Professor H. E. ARMSTRONG, *F.R.S.*, Professor WYNDHAM R. DUNSTAN, *F.R.S.*, Mr. C. H. BOTHAMLEY, *and* Mr. W. A. SHENSTONE (*Secretary*).

THE work of the Committee has been actively continued during a considerable part of the past year.

The various preliminary difficulties involved in the preparation of pure materials, and especially of chlorine, have now been largely overcome, and it is anticipated that considerable progress will be made during the coming year in investigating the behaviour of highly purified chlorine, and the Committee ask to be reappointed for this purpose.

A considerable part of the grant made to meet expenses already incurred in 1894 remains in hand, and therefore it is not necessary to ask for a further grant this year.

How shall Agriculture best obtain the Help of Science? By R. WARINGTON, *M.A., F.R.S., Professor of Rural Economy, Oxford.*

[Ordered by the General Committee to be printed *in extenso.*]

OUR discussion to-day will, I trust, have practical results. The time is certainly ripe for decided steps being taken. No doubt exists in the mind of any one that British agriculture is in great need of some powerful helping hand, which, in popular phraseology, shall 'put it on its legs again.' There is probably also no doubt in the mind of any person in this room that, if the farmer is to be enabled to do his best, agriculture must be advanced from its original condition as an art, and that in future its operations must be conducted with the full assistance of natural science. The so-called 'practical man' may indeed believe that the question we have met to discuss will be at once set aside as profitless if we raise the preliminary question, Do you believe that the assistance of natural science will remove agricultural depression ? I answer at once that I do not know that it will, but that this is no reason for declining the aid which science offers. When a sick man calls in a physician he does not ask the preliminary question, Do you promise to restore me to full health ? If the question were asked, the physician would positively decline to make any such promise ; and yet the sick man would place himself unreservedly in the physician's hands, feeling that he could not do better than make use of the best knowledge of the day on the subject of his complaint. Now agricultural science should mean the best knowledge of the day on the subject of agriculture, and a farmer will surely do wisely to obtain the aid of this knowledge in all his operations.

We have now to consider in what manner, by what methods, agriculture may best obtain the aid of science. We might divide our answer to this question into two parts. We might say, in the first place, that the science of agriculture is still only in its infancy, and that if agriculture is to be effectively aided by science it is necessary that there should be a great increase in the number of practical investigations of agricultural questions. In the second place, we should add, that all the investigations already made, or to be carried out, will fail of practical utility if the farmer remains uninformed of the knowledge thus acquired. Our answer would thus be, that we require, firstly, an extended system of practical investigations; and, secondly, an effective scheme of agricultural education. All that will be said to-day could probably be classed under one or other of these two heads. I propose, however, in these opening remarks to adopt a less logical division of the subject. In order that our discussion may not assume an academic character, but may, if possible, lead to some practical result, I will at once descend into the region of practical politics, and endeavour to answer the question by pointing out what can most usefully be done by (1) a Board of Agriculture, and (2) by County Councils, to accomplish the objects of agricultural investigation and agricultural education, which we believe to be so important.

There are certain kinds of work which can be accomplished best by a central organisation; work which is of general, national importance; work which is necessary to form the basis of future developments. Such work should be at once undertaken by the Government, through a Department of Agriculture.

We need a really complete agricultural and horticultural library, freely open to the public. The literature of the subject is extremely large and rapidly increasing; much of it is quite beyond the reach of a private individual, while it is of too special a character to be found in our ordinary public libraries. To give one illustration. There are at the present time about 300 fully equipped experiment stations in Europe and America, besides many smaller institutions. The results of their investigations are published in numerous reports and journals in many languages. No person is able at present to refer to more than a small part of this literature. Instead of consulting the original papers, one is generally obliged to be content with the meagre abstracts furnished by a German *Jahresbericht* or *Centralblatt*, and whatever does not find entrance into these periodicals is lost to the general public. As an illustration of what may be done in this direction by an energetic Board of Agriculture, I may mention that the Department of Agriculture in the United States compiles a card catalogue of all the published work of the fifty-five American experiment stations, and supplies a copy of this catalogue to each station.

We need also an English journal published monthly, in which the results of the most important agricultural investigations should be made accessible to the general scientific public. The advantage of this to teachers and investigators would be very great. As such a journal could not be expected to pay its expenses, it should be published for the benefit of the country by the Government. The American 'Experiment Station Record' is an example of work done in this direction: it is chiefly, but not exclusively, concerned with the investigations made at the American stations.

Another piece of work which belongs peculiarly to a central department is the collection and preparation of national statistics. Statistics of acreage under different crops, with the annual and average produce per acre, and the number of live stock in the United Kingdom, are collected and published by the present Board. The Board that we desire would go much further in this direction. We have at the present time no accurate idea of what is the average composition of any portion of our agricultural produce, for the simple reason that the collection of the scattered analyses, the rejection of imperfect work, and the averaging of the remainder is so large an undertaking that no private individual has had the courage to attempt the task. The results of this present lack of national information are not unimportant. We are obliged at the present time to employ German averages for all purposes of teaching or calculation. These averages are in the main prepared from German analyses, and relate to crops and foods grown in a different climate, and under different conditions, to our own. In the United States, the want of national statistics respecting the composition of foods and crops has been supplied by their Department of Agriculture, which has published in one volume more than 3,000 analyses of American-grown foods, all properly classified and averaged. In the same way the results of American digestion experiments, made exclusively with American foods and American animals, have been collected and published, thus again obviating the necessity for relying solely on German figures.

An efficient Department of Agriculture should be provided with a staff of officers representing all the sciences connected with agriculture; these officers should be furnished with suitable laboratories, and all the machinery required for carrying out investigations and making reports. Thus equipped the department would be able to attempt the solution of agricultural problems of pressing importance. The work done at this Government institution would also serve as a model for the investigations carried on at the smaller experiment stations. The investigations thus conducted with public money should be of a thoroughly practical character, the results of which would have a direct bearing on the farmer's work. Let me venture on a single illustration. Persian barley has lately been imported into England in considerable quantity; its price has been lower than that of any other kind of barley in the market. A question at once arises in the mind of the cattle-feeder, Is it really cheap? Will a sovereign expended on these thin, shrivelled grains purchase a greater weight of food substance, and fatten an animal better, than the same money spent on English barley? The farmer can neither make a chemical analysis nor carry out an accurate feeding experiment, but a properly equipped Department of Agriculture could do both, and in a few weeks issue a report which would be of substantial benefit to the farmers of this country.

Before leaving this part of the subject let us note what our brethren across the water are doing in this matter. Canada, though a poor country, and with a population of only five millions, has its central agricultural laboratories, and its chemists and botanists employed under its Department of Agriculture, and spends 15,000*l.* a year on the agricultural investigations conducted at the central station at Ottawa and at the four provincial stations. In the United States the annual cost of the investigations carried out by the Central Department of Agriculture at Washington cannot be less than 60,000*l.*, and this is exclusive of the cost of the work done at the fifty-five experiment stations in the various States, towards which 150,000*l.* is annually contributed by the National Government.[1]

[1] The figures quoted, both for Canada and the United States, do not include the very considerable sums spent for the same objects by the local governments in these countries.

We may certainly congratulate ourselves that we have at last a Board of Agriculture, presided over by a Minister having a seat in the Cabinet. The work done by the Board has already been of considerable benefit to the country. What we desire is that far larger means should be placed at its disposal; that the scope of its work should be enlarged; and that, especially, it should acquire a distinctly scientific character, which, as we have already remarked, simply means that the best knowledge of the day should be enlisted in the service of agriculture. We shall feel ashamed, I think, when I mention the sum at present devoted by the Board to the purpose of investigation. The grants made for education and investigation in the year 1894–95 may be summarised as follows:—

Collegiate centres	£5,550
Dairy institutes	950
Instruction in forestry	250
Investigations by various associations	650
	7,400

Thus 650*l.* is the whole sum directly devoted by the Board to the purpose of investigation: some portion of the sums contributed to collegiate centres may, however, be employed for this purpose, as experiments are conducted by some of the colleges thus assisted.

The 6,750*l.* distributed by the Board to educational institutions is very wisely allotted to those giving a complete course of instruction. The provision of a full course of training for teachers should always have the first consideration in any educational movement.

In referring to the present national expenditure on agricultural education we must not omit the grants made by the Department of Science and Art to science schools and classes teaching the principles of agriculture. The total grant amounted in 1893–94 to the sum of 2,937*l.* The Department has recently attempted to improve the instruction given in these classes. A new syllabus of the subject has been prepared for the use of the teachers, with suggested experiments, and a few necessary diagrams. The Honours examination has also been made much more thorough.

We next turn to the work done in this country by local authorities. This is a very wide subject, and I can only glance at a few points. We all know that a really large sum of national money has been placed in the hands of the local authorities during the last few years, which they can use at their discretion for the purposes of technical and secondary education. The sum thus placed at the disposal of the local authorities in England for the year 1894–95 amounted to about 744,000*l.*, of which about 600,000*l.* was actually spent on education. The particular educational objects aided vary, of course, very much in different localities, and it is only in the counties that we can expect to find the teaching of agriculture occupying an important place. The annual grant at the disposal of the English counties somewhat exceeds 400,000*l.* It is very difficult to tell how much of this is devoted to agricultural purposes. In the case of a few counties, as Kent, Bedfordshire, and Berkshire, it would appear from the figures published in the 'Record of Technical and Secondary Education'[1] that about one-third of the total grant is

[1] I am indebted to the reports in this valuable periodical for much of the information here given respecting the agricultural work of County Councils.

allotted to agriculture, but in most counties the proportion is very much less.

The mode in which this agricultural education is carried out is, of course, very varied. It may consist simply in money aid to classes under the Department of Science and Art; or the county may have its own travelling lecturers, who deliver short courses on agriculture, horticulture, dairy-work, poultry, bee-keeping, and the diseases of animals. Purely technical classes on horse-shoeing, ploughing, hedging, draining, are also common. The most popular, and certainly one of the most useful, of these technical schools is the travelling dairy, by which practical instruction in butter-making is given at many centres throughout the county. As a help to a higher grade of instruction than is furnished by these popular classes, the County Councils grant agricultural scholarships available for the courses of instruction at agricultural schools and colleges, and in some instances at institutions of university rank. In a few cases dairy institutes and agricultural colleges have been established by County Councils, usually by the united action of two or three counties, and in these cases considerable sums are annually set aside for their support. The sketch we have given of County Council work will, however, leave a far too favourable impression if we do not bear in mind that only a portion of the schemes mentioned are generally in use in any one county.

As it is clearly most important that these new schemes of agricultural education should be wisely and efficiently carried out, we may profitably devote a few minutes to the consideration of some important points upon attention to which any real success will largely depend.

With lads of the age at which they are usually in attendance at elementary schools little can be done in teaching the scientific principles of agriculture; such lads have not acquired the previous scientific knowledge necessary for understanding what is to be taught. They may indeed learn off answers to questions either from the blackboard or from a printed text-book, and thus furnished they may pass examinations; but the knowledge they have acquired is merely a knowledge of words, and will be of no value to them in after-life. The foundation of habits of observation and logical reasoning must, however, be laid in the elementary school if higher instruction is hereafter to be given. This elementary training may easily be made to have an agricultural bias. No better means of educating a boy's powers of observation can be found than a study of the individual characters and modes of development of the various crops, weeds, and insects of the farm.

When lads have passed through the elementary school their special training should immediately commence; any delay is most unfavourable to the boy's development. The time has now come when a distinction has to be made between the students; some are to be labourers, some are to be farmers. For both technical instruction is required: the arts of agriculture have to be mastered.[1] The farmer's son, however, requires besides this a higher course of study if scientific principles are to be introduced into his future practice. One great need of the present day is the establishment of secondary agricultural schools, which shall be centres both for

[1] In some countries, as Ireland and France, instruction in the art of agriculture is given in connection with the elementary schools: this is, of course, possible if the school engagements admit of time being thus spent, and there is convenient land adjoining.

purely technical and for scientific instruction. The farmer's son on entering such a school would commence at once his technical training, and he would at the same time commence the study of elementary chemistry and elementary biology and geology. Not till he had gone through elementary courses on these subjects would he be prepared for instruction in the scientific principles of agriculture.

It is from well-arranged schemes, in which the instruction proceeds from first to last in a proper order, that the best results are to be expected; such schemes should gradually be made to take the place of the short miscellaneous courses of instruction, imperfect in themselves, and given to an audience unprepared for them. The principal use of popular lectures is undoubtedly to arouse a general interest in the subject, and to show how much there is to be learnt on agricultural matters. Miscellaneous lectures have thus a great value in pioneer work, but it must never be supposed that they can take the place of solid, systematic instruction.

Lectures to farmers are undoubtedly of very considerable importance, as they are one of the few means of improving the practice of the present generation, but they are the most difficult of all lectures to carry on efficiently. The lecturer must be thoroughly acquainted with farming practice, and with the conditions which determine profit and loss, or he will bring his science into contempt. The teaching of science as science to an audience of farmers will soon result in an empty room; but keen, practical men will listen carefully to the conclusions drawn from scientific investigations when these can be shown to have a direct bearing upon their daily work.

One of the greatest obstacles to the teaching of scientific agriculture in the present day, whether in schools or in evening classes or lectures, is the great lack of competent teachers. The best qualification which a teacher can offer is that of graduate of one of the larger agricultural colleges, but the supply of such men is extremely small. The qualification sufficing for teaching the principles of agriculture under the Department of Science and Art is an extremely low one,[1] and should never in itself be accepted as sufficient. A poorly qualified teacher solves all his difficulties by adopting a popular text-book, and teaching this in a literal manner. Unfortunately some of the text-books most largely used entirely fail to represent the present condition of agricultural science, and persistently teach a whole series of exploded errors. Technical committees should not sanction the use of text-books of scientific agriculture which are mere reprints of works written many years ago.

County Councils should recollect that all educational machinery requires inspection. They act unadvisedly when they try to rid themselves of trouble and responsibility by making grants to Parish Councils for technical education, and then leaving them to direct the work. It is necessary always to ascertain how a teacher does his work. Does he illustrate his lessons by specimens, diagrams, and experiments; or is his object simply to cram for a written examination? Opportunity should be given to teachers to improve themselves by further study. Schemes for Saturday

[1] A person becomes qualified to conduct a class under the Department by answering successfully six or seven questions, selected by himself out of twelve or fourteen, from a paper drawn up to suit the capacity of lads of fifteen. The new regulations for the Honours examination, which come into force next year, will provide a much higher qualification, as the successful candidates will in this case have passed two examinations subsequent to the one just named.

lectures to teachers, or classes for teachers held in the vacation months, are of the greatest use if good men can be secured as instructors.

We must now speak of the relations of County Councils to agricultural investigation. This kind of work has been undertaken at present by only a few counties, and by them to a very limited extent: public opinion is, indeed, not nearly so developed upon the subject of investigation as it is on that of education. Practical investigations are, however, urgently required if the operations of agriculture are to be carried out in a scientific manner. The science of agriculture is, in fact, as yet in its infancy, and can be perfected only by well-arranged experiment. There is room for an immense variety of work. Every substance which the farmer uses, every living organism (plant or animal) with which he is concerned, every operation he conducts, must be thoroughly understood if it is to be employed to the best advantage. Great Britain is singularly behind other civilised countries in the work of agricultural investigation. The reason has apparently been very simple. In most European countries, and in the United States and Canada, the initiative has been taken by the Government. Ministers, having a just idea of the conditions on which national prosperity depends, have succeeded in obtaining public funds for the support of experiment stations, institutions provided with laboratories and skilled workers, and devoted to the elucidation of agricultural problems. The German Empire alone has about fifty-four *Versuchs-Stationen*, without reckoning the public laboratories occupied chiefly with the analysis of manures and seed-testing. In England agricultural investigation has been left to private enterprise, which during the present century has produced one first-class experiment station—that of Rothamsted—of which we are all rightly proud, but which is wholly inadequate for the growing needs of the country.

I am not at this moment advocating the immediate creation of many first-class experiment stations, though there is ample scope for such in the hands of competent workers. One first-class station should certainly be at once started under the immediate control of a reorganised Department of Agriculture, as without this the national investigations, which would become one of the functions of this department, could not be carried out. The great need at the present time is the creation of numerous local stations, to work upon the practical problems of each locality, and so become centres of scientific teaching and scientific demonstration. If Parliament were to offer to give 1,000*l.* a year[1] towards the support of a county experiment station, erected and maintained by the County Council, and subject to the inspection and approval of the Department of Agriculture, a great start would be at once made in the right direction.

A few words may be said as to the kind of investigations to be undertaken by a local experiment station. The subjects taken up will of course depend upon the style of farming in the neighbourhood, the object being in every case to bring scientific knowledge and methods into actual touch with the farmer's work. Some of the experiments would be carried out on selected farms, possessing soils and climates typical of considerable areas in the county. Comparative trials of different

[1] This should be regarded as a minimum sum. In the United States each State receives 3,000*l.* annually from the National Exchequer towards the maintenance of its experiment station.

varieties of grain, root, or fodder crops upon the various soils of the locality would be most useful.[1] Farmers usually go on sowing the same kind of seed, or make a change only to something that is well advertised, without ever ascertaining by actual experiment which of the manifold varieties in the market is best fitted for the conditions of their own soil and climate. Other experiments could only be conducted at the experiment station. It is to be hoped that comparative trials of the nutritive value of different foods would in all cases be undertaken: on this point our knowledge is sadly deficient.[2] The chemical analysis of foods, as conducted at the present day, is no sufficient guide to their feeding value. We need facts as to the actual effect of different foods upon the animal, and we must then seek to bring our methods of analysis into consonance with these facts.

Besides actual investigations these local agricultural stations might be made to supply demonstrations which would be invaluable for teaching purposes. If, however, agricultural secondary schools are established, such demonstrations would find their most suitable home in these establishments. It will probably be desired in some cases to make the experiment station a place for the analysis of manures and feeding stuffs for the farmers round. If a special assistant is allotted to this kind of work there can be no objection to it; but it would be folly to allow investigations to be interrupted by attention to such matters.

At the present time the majority of the County Councils have not made any commencement in agricultural investigations. Those councils which have taken up the subject appear generally to have avoided any responsibility of their own in the matter. The usual course has been to make a grant to some agricultural college, or to some local Chamber of Agriculture, on the understanding that they will carry on experiments in the county. There is surely, however, no reason why a strong agricultural committee should not be formed in every county by the addition to their number of experts residing in the county. The experiments at present carried on through the medium of agricultural colleges and Chambers of Agriculture are almost all of one type: they consist of the comparative trials of manures. This style of experiment is indeed the only one which has found general favour in this country. The fact is certainly regrettable, as it exhibits a poverty of idea on the part of the experimenter, and a lack of apprehension of the many serious problems which are awaiting solution.

Many important topics have been left unmentioned which will doubtless be taken up during the discussion which is to follow. My object has been merely to give a brief sketch of the kind of national and local work required if a real effort is to be made to give agriculture the aid of science.

[1] In Essex and Nottinghamshire a commencement has been made of work of this kind.

[2] In Norfolk valuable experiments have been made on the feeding value of oil-cake containing different percentages of oil.

High-level Flint-drift of the Chalk.—Report of the Committee, consisting of Sir JOHN EVANS (*Chairman*), Mr. B. HARRISON (*Secretary*), Professor J. PRESTWICH, *and* Professor H. G. SEELEY. *Drawn up by* Mr. B. HARRISON.

THE Committee were appointed to investigate the nature and probable age of the High-level Flint-drift in the face of the chalk escarpment near Ightham, which appears to be productive of flakes and other forms of flint probably wrought by the hand of man.

This patch of gravel has been preserved upon a promontory of the chalk escarpment, at an altitude of 658 feet. It extends for some 70 yards, and attains a maximum thickness of 5½ feet.

It is composed chiefly of sharp angular flint, varying in colour from bluish-white to bleached-white. Accompanying this is a quantity of deeply-stained ochreous flints, with here and there pieces of chert, Oldbury stone, and rag.

Flakes made by man exist in thousands, and they preponderate over the more elaborately worked specimens. Numerous scrapers, hollow-notched and of horse-shoe shape, were obtained, as well as partially finished implements; but no perfect large tools, and none with any sign of polishing.

The worked-flint material is similar to that spread out in the Holmesdale valley, where it is accompanied by large somewhat rude implements. Amongst the deep ochreous flints some bear the look characteristic of the plateau specimens. The matrix is usually clayey, of a dark red colour, but in places it is quite chalky, and unstratified. A large quantity of the flints are encrusted with carbonate of lime. With the view of tracing the origin of this bed attention was directed to the ground above, in hope of finding either a Neolithic settlement, or plateau implements *in sitû.* The latter having been traced to a position where an excavation had brought them from a depth of six or seven feet (Pit A), it was decided to dig a pit to obtain a section upon Parsonage Farm, Stanstead, by the kind permission of the owner, Mr. Pink.

The excavation was closely watched by Mr. W. J. Lewis Abbott, F.G.S., and myself, and occasional visits were made by the Rev. R. Ashington Bullen, F.G.S, acting under direction of Professor Prestwich, Mr. F. J. C. Spurrel, Mr. Corner, F.G.S., and others interested in the subject.

The following is the section (see p. 350).

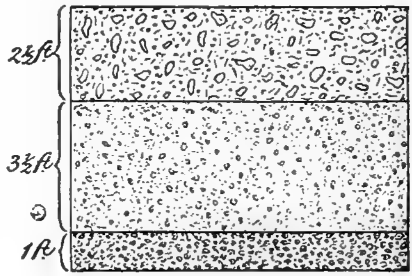
Work was commenced on October 19, 1894, by digging a pit 12 feet by 6 across. At the top, 2½ feet consisted of a stony loam, with a large percentage of ochreous flint, much worn, angular white flint, Tertiary pebbles, and some evidence of southern drift. With a fairly even line of demarcation came a grey loam containing some small fragments of flint, a few small Tertiary pebbles, and small rudely worked stones scattered throughout at places. At about 5½ feet this loam became more clayey, and of a deep rich ochreous colour, overlying a gravel, about 12 inches in thickness, composed of much-worn ochreous flints, some very large, and many Tertiary pebbles. This gravel was hard and compact. From it I secured very many worked implements. Heavy rain now hindered work by filling the pit. Measuring off 12 feet in line we began to dig another pit.

Pit 1. *Parsonage-farm, near Ash, Kent.*

Humus and drifted material, white flints, pebbles, and many ochreous flints worn and worked.

Grey loam, with scattered small pebbles, and a few small worked ochreous flints throughout; the lower part of this deposit was more clayey and deeply ochreous.

Gravel, about 12 inches thick, varying, confusedly laid, very hard and compact; pebbles, large flints, and many bearing work.



Pit 2. *Parsonage-farm, near Ash, Kent.*

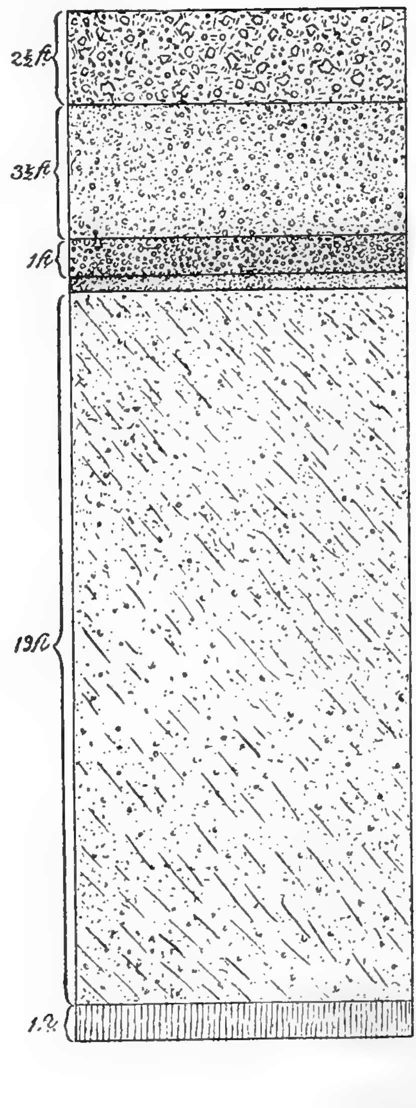
Humus and drifted material, white flints, pebbles, and many ochreous flints, worn and worked; one piece of Oldbury stone.

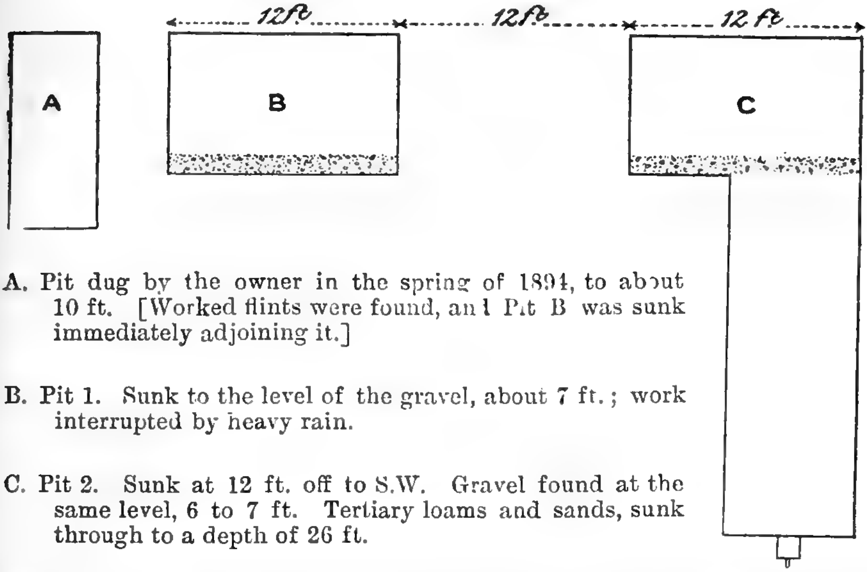
Grey loam, with scattered small pebbles, and a few small worked ochreous flints throughout; the lower part of this deposit was more clayey and deeply ochreous.

Gravel, about 12 inches, varying, confusedly laid, hard and compact; pebbles, large flints, many bearing work. A few worked flints were found, at 8 feet, in one spot.

This pit dug to a depth of 26 ft., passing through sandy loams obliquely bedded; lower Tertiary pebbles.

One foot tested by a hop-pitcher (iron bar); no sign of chalk.





A. Pit dug by the owner in the spring of 1894, to about 10 ft. [Worked flints were found, and Pit B was sunk immediately adjoining it.]

B. Pit 1. Sunk to the level of the gravel, about 7 ft.; work interrupted by heavy rain.

C. Pit 2. Sunk at 12 ft. off to S.W. Gravel found at the same level, 6 to 7 ft. Tertiary loams and sands, sunk through to a depth of 26 ft.

Pit No. 2 presented precisely similar conditions, 2½ feet of surface drift, the grey loam, with its weathered pebbles and few small worked stones, continuing until the ochreous clayey deposit was reached which overlay a continuation of the gravel.

In this pit, however, the gravel was much stained at places and hardened throughout by manganese. The seam of gravel proved to be about 12 inches in thickness, varying at places. At one spot in this pit, at a depth of 8 feet, a few worked stones were found lying in a sandy matrix; but below this, although a depth of 26 feet was pierced, no further evidence of worked tools was found.

As the object was to investigate the nature of the deposits and to reach the Chalk if possible, the work was continued until a depth of 26 feet was reached when, owing to the men working in danger of a slip, and being so well in the Tertiaries, orders were given to fill in. At 26 feet a hop-pitcher (iron bar) was used to pierce about a foot more, but no evidence of the chalk was forthcoming.

The Volcanic Phenomena of Vesuvius.—Final Report of the Committee, consisting of Mr. H. Bauerman (*Chairman*), Dr. H. J. Johnston Lavis (*Secretary*), Mr. F. W. Rudler, *and* Mr. J. J. H. Teall, *appointed for the purpose of Investigating the Volcanic Phenomena of Vesuvius and its Neighbourhood.*

The reporter having since the last meeting of the Association terminated his residence in Naples, the continuous observations of the volcanic phenomena of the district which he has carried on during the last sixteen years have naturally come to an end. It is therefore not considered advisable to ask for the reappointment of the Committee. In closing the work of the Committee the reporter wishes to express his sincere thanks for the valuable aid he has received.

An account of the eruption during the early months of this year was published by the reporter in 'Nature' of August 8, 1895.

The Rate of Erosion of the Sea-coasts of England and Wales, and the Influence of the Artificial Abstraction of Shingle or other Material in that Action.—Fourth Report of the Committee, consisting of Mr. W. WHITAKER (*Chairman*), Messrs. J. B. REDMAN *and* J. W. WOODALL, Major-General Sir A. CLARKE, Admiral Sir E. OMMANNEY, Admiral Sir GEORGE NARES, Captain J. PARSONS, Admiral W. J. L. WHARTON, Professor J. PRESTWICH, Mr. EDWARD EASTON, Mr. J. S. VALENTINE, Professor L. F. VERNON HARCOURT, *and the late* Mr. W. TOPLEY, *and* Mr. C. E. DE RANCE (*Secretaries*). (*Drawn up by* C. E. DE RANCE.)

THE seaboard counties of England and Wales are twenty-nine in number: of these Cornwall has the largest amount of coast, with a curiously indented outline of hard Palæozoic rocks; the county of Devon stands next with similar rocks, except on the south-eastern coast, where Secondary rocks form the coast-line, and the rate of waste is considerable. The counties of Lancashire and Yorkshire stand next, and are margined by Secondary rocks and Drift, and the rate of erosion is excessive. Sussex and Kent stand next as regards length of coast-line, and are wholly composed of more or less soft Secondary and Tertiary deposits, offering a ready prey to the devouring waves, often increased by badly designed works of so-called protection. The last remarks apply to the coasts of the whole of the remaining counties of England, except Northumberland, where Upper Palæozoic Coal-Measures and Permians are being moderately wasted by coast erosion, and Cumberland, where also, through the ancient hard rocks of the Lake District being sea-margined by Coal-Measures and Glacial Drift, very considerable coast erosion is taking place. Similarly in Wales the hard rocks of the Cambrian Mountains are, or were, margined by terraces of soft Coal-Measures and red rocks in Flintshire, Glamorganshire, and Pembrokeshire; and even in the western coast the sites of terraces of Drift once present now underlie high-water mark; a process which would have been still more marked in North Wales had not the London and North-Western Railway run for so many miles along its base, necessitating that company keeping out the inroads of the sea.

Your Committee was appointed in 1881, at York, at the suggestion of the surviving Secretary, who acted as Chairman in that year, his place being taken by Sir John Hawkshaw in 1882, who was succeeded by Mr. R. B. Grantham between 1883 and 1889. Since 1890 Mr. W. Whitaker has been Chairman. A preliminary Report, giving the form of inquiry adopted by the Committee and widely circulated by them, was given in 1884, and detailed Reports appeared in 1885, 1886, and 1888: they embodied a very large mass of facts of great value, given through the courtesy of several public departments. No grant of money has been made since 1887. The three Reports published were edited by the late Mr. W. Topley, whose loss your Committee have deeply to deplore, as doubtless his judgment would have greatly aided them in formulating the resolutions embodied in this Report, in the production of which they are also deprived by death of two of their former Chairmen, Sir John Hawkshaw and Mr. Grantham.

In the preliminary Report of your Committee in 1884 it was stated that 'the importance of the subject referred to' them 'for investigation is universally admitted, and the urgent need for inquiry is apparent to all who have any acquaintance with the changes which are in progress around our coasts. The subject is a large one, and can only be successfully attacked by many observers working with a common purpose and upon some uniform plan.' Since that date important changes have taken place, affecting both divisions of the reference of inquiry. The success of the British Association in initiating the investigation of the more important subjects now being undertaken by the provincial corresponding scientific societies has resulted in offers of assistance from an increasing number of observers able and willing to collect facts locally all over the United Kingdom; and your Committee are of opinion that the necessity for their existence has ceased, and that the work could be successfully carried on by local effort. The local information, however, so acquired cannot be readily obtained for public purposes when only locally published, and it appears to them that the corresponding societies might usefully furnish their results annually to some department of the public service.

Your Committee, nevertheless, consider that, valuable as would be the results obtained locally in some districts by the local scientific societies, there are large areas where no such societies exist, and many where they might not care to undertake the work; and, further, that the work, however well carried out, is, in some cases, simply the noting of the erosion of coasts, the destruction of churches, forts, villages, and coastguard stations which they are powerless to prevent. They are of opinion that the abstract of information obtained, herewith appended, is amply sufficient to show the imperial necessity of preserving the area of this country from the inroads of the sea in an efficient manner. It also proves that the work of devastation is largely aided by artificial operations of two classes: *first*, the abstraction and selling of shingle, sand, cement-stone, and other rocks; *second*, by badly designed preservation works, sea-walls without sufficient land ties or concrete backing, and with bad foundations and ill-designed slopes; groynes of unsuitable material, incorrect construction, and improper direction to meet the storm-waves at such angle as to arrest and detain the shingle brought to them.

As pointed out by Mr. Redman in 1885, the legal aspect of the case is ably brought out in Hall's 'Essay on the Rights of the Crown to the Sea-shore,' republished in 1875 by Mr. Loveland Loveland, of the Inner Temple, from which it appears that the 'dominion or ownership over the British seas, vested by law in the King, extends not only over the open seas, but also over all creeks, arms of the seas, havens, ports, and tidal rivers, as far as the reach of the tide,' and, further, 'is not confined to the mere usufruct of the water and the maritime jurisdiction, but it includes the very *fundum* or soil at the bottom of the sea.' And it is further stated that 'with regard to the "constant and usual fetching of sea sand, seaweed, and gravel, between the high-water and low-water mark, and licensing others so to do, and embanking against the sea, and enjoyment of what is so *inned*"—these, it must be admitted, are all acts likely to be done by the owners of the soil, and they afford colour that he who does such acts is the owner; but these acts may be usurpations or intrusions on the King's ownership, and *primâ facie* are so.'

The late Mr. R. B. Grantham, M.Inst.C.E., F.G.S., in 1888, then Chairman of the Committee, stated—what is equally true in 1895 in the light of experience gained in the interval—that 'the papers hitherto prepared are very valuable; but they are unconnected, and do not give the means of enabling us to promote a system of protection in all parts of our coasts. It seems essential that the information, to be practically useful, should point out how a connected method of proceeding and operation could be formed to prevent the wearing away of land.'

The preservation of the coast, and the conservation of our seaboard counties, are matters of urgent necessity:—they affect many varied interests—the Government, County Councils, Crown rights, and private ownership, but as to the department which should take charge of the work, the Committee do not offer any suggestion; they are unanimous as to how a working result could be most quickly obtained.

APPENDIX I.

SUMMARY OF PREVIOUS REPORTS.

Form of Inquiry circulated.

1. What part of the English or Welsh Coast do you know well?
2. What is the nature of that coast?
   a. If cliffy, of what are the cliffs composed?
   b. What are the heights of the cliffs above H.W.M.? Greatest; average; least.
3. What is the direction of the coast-line?
4. What is the prevailing wind?
5. What wind is the most important—
   a. In raising high waves?
   b. In piling up shingle?
   c. In the travelling of shingle?
6. What is the set of the tidal currents?
7. What is the range of tide? Vertical in feet. Width in yards between high and low water. At spring tide; at neap tide?
8. Does the area covered by the tide consist of bare rock, shingle, sand, or mud?
9. If of shingle, state—
   a. Its mean and greatest breadth.
   b. Its distribution with respect to tide-mark
   c. The direction in which it travels.
   d. The greatest size of the pebbles.
   e. Whether the shingle forms one continuous slope, or whether there is a 'spring full' and 'neap full.' If the latter, state their heights above the respective tide-marks.
10. Is the shingle accumulating or diminishing, and at what rate?
11. If diminishing, is this due partly or entirely to artificial abstraction? (See No. 13.)
12. If groynes are employed to arrest the travel of the shingle, state—
    a. Their direction with respect to the shore-line at that point.
    b. Their length.
    c. Their distance apart.
    d. Their height—
       (1) When built.
       (2) To leeward above the shingle.
       (3) To windward above the shingle.
    e. The material of which they are built.
    f. The influence which they exert.

13. If shingle, sand, or rock is being artificially removed, state—

a. From what part of the foreshore (with respect to the tidal range) the material is mainly taken.
b. For what purpose.
c. By whom—Private individuals. Local authorities. Public companies.
d. Whether half-tide reefs had, before such removal, acted as natural breakwaters.

14. Is the coast being worn back by the sea? If so, state—

a. At what special points or districts.
b. The nature and height of the cliffs at those places.
c. At what rate the erosion now takes place.
d. What data there may be for determining the rate from early maps or other documents.
e. Is such loss confined to areas bare of shingle?

15. Is the bareness of shingle at any of these places due to artificial causes?

a. By abstraction of shingle.
b. By the erection of groynes, and the arresting of shingle elsewhere.

16. Apart from the increase of land by increase of shingle, is any land being gained from the sea? If so, state—

a. From what cause, as embanking salt-marsh or tidal foreshore.
b. The area so regained, and from what date.

17. Are there 'dunes' of blown sand in your district? If so, state—

a. The name by which they are locally known.
b. Their mean and greatest height.
c. Their relation to river mouths and to areas of shingle.
d. If they are now increasing.
e. If they blow over the land; or are prevented from so doing by 'bent grass' or other vegetation, or by water channels.

18. Mention any reports, papers, maps, or newspaper articles that have appeared upon this question bearing upon your district (copies will be thankfully received by the Secretaries).

19. Remarks bearing on the subject that may not seem covered by the foregoing questions.

N.B.—Answers to the foregoing questions will in most cases be rendered more precise and valuable by sketches illustrating the points referred to.

First Report.[1]

In this report is included *General Report A*, 'On the South-eastern Coast of England,' by Mr. J. B. Redman, C.E. He points out the disasters which inevitably follow injudicious interference with the littoral movements of beach, and that the erosion of the south-east coasts by the action of wind-waves is assisted and increased by artificial agency, by removal of material, and by the treatment of works of defence in a selfish spirit, unaccompanied by concerted action, resulting in injury to adjoining frontages for the benefit of those operated on, and he states that this is abundantly illustrated in the records of such public departments as the Admiralty, Woods and Forests, Office of Works, the Board of Trade, the Trinity Corporation, and by the experience of nearly every harbour board, river conservancy, and local drainage and sewage authority; and he refers to the Blue Books of the House of Commons as regards tidal harbours, harbours of refuge, lighthouses and shipping, showing the confusion caused by the division of local authority, and personal opposition of lords of the manor to imperial requirements as to the conservation of the British Isles from the ravages of the wind-wave, accelerated by the wholesale

[1] *Brit. Assoc. Report*, 1885, pp. 404–465.

removal by 'ballastage' for road-making and building purposes, and improper and badly conceived engineering works.

General Report B.—'The South-eastern Coast of England,' by Colonel E. C. SIM, R.E. (Retired). Shows severe loss of coast where public preservation works are neglected, and the value of their being carried out on scientific principles. Groynes are valuable to check movement of shingle, and to tie the foot of sea-walls and prevent their being undermined; an 80-foot groyne protects only 100 feet of coast; they should be directed towards the prevailing dangerous winds, and if the coast suffers from both south-east and south-west winds, land ties on both sides are necessary, and in all cases the groynes should be so built as to get the beach to topple over and accumulate on the leeward side as well as the windward.

General Report C.—'Erosion of Sea-coast, Langney (or Langley) Point, and Beachy Head, Sussex,' by F. W. BOURDILLON, M.A., Eastbourne. Shows that the removal of reefs of Upper Greensand rocks between tide-marks has caused coast erosion, and the necessity of numerous strong groynes.

General Report D.—'The Coast of East Kent,' by G. DOWKER, F.G.S. Sketches taken of Pegwell Bay between 1849 and 1884 show great erosion.

Detailed Reports.—1. 'Sidmouth,' by PETER ORLANDO HUTCHINSON. Groynes entirely failed, and an esplanade wall had to be built. Considers the land is subsiding beneath the sea at the rate of 10 inches per 100 years.

2. 'Lyme Regis and Charmouth,' by R. B. GRANTHAM. This report does not refer to the destruction of the cliff between the places named, and the fall of a churchyard at their westward end. The rate of erosion is much facilitated by the removal of 'cement stones' at the base of the cliff.

3. 'Axmouth to Eype,' by HORACE B. WOODWARD. Quotes much local information; annual waste of cliff about 3 feet per annum in soft rock and 1 foot in hard.

4. 'Bridport Harbour,' by H. B. WOODWARD. About 10,000 tons of shingle removed away in six months, stated to be sometimes replaced in a single tide.

5. 'Weymouth,' by BERNARD H. WOODWARD. Removal of shingle now prevented; groynes washed away in 1883.

6. 'Christchurch to Poole,' by Rev. G. H. WEST, Bournemouth. Removal of ironstone forming natural groyne has caused shingle to travel.

7. 'Sandown Bay,' by Lieut.-Col. GARNIER, R.E., Parkhurst, Isle of Wight. States the groynes east of Sandown to protect sea-wall do not appear to have prevented the accumulation of shingle at Yaverland.

8. 'Brading Harbour,' by R. B. GRANTHAM, M.Inst.C.E., F.G.S. Half and full tide reefs have protected the coast.

9. 'Bembridge, &c., Isle of Wight,' by Lieut. NORRIS, R.E. The serious loss of rich land, due to pressure of land drainage of 'blue slipper,' in the 'undercliff'; there is only one 3-inch weephole to 8 yards of wall, which is wholly insufficient.

10. 'Pagham,' by R. B. Grantham, M.Inst.C.E., F.G.S. Reclaimed lands safely sustained by taking land water in tunnel through natural shingle bank to low water on sea-front.

11. 'Worthing to Lancing,' by R. B. GRANTHAM, Inspector under the Land Commissioners. Groynes 200 feet in length, 500 feet apart, set at angle of 63° to 80° to coast line, 15 in number, supported by land ties, cause effectual accumulation of shingle.

12. 'Lancing to Shoreham,' by R. B. GRANTHAM. Groynes similar to

above, built in 1877–8, have cost nothing since, and caused great increase of shingle.

13. 'Littlehampton to Brighton,' by W. E. C. NOURSE, F.R.C.S. Gives examples of medium-sized groynes, giving good results, but extra sizes give no protection ; the coast generally is wasted and lowered, and many buildings destroyed.

14. 'Newhaven and Seaford,' by A. E. CAREY, Resident Engineer, Newhaven Harbour Works, Sussex. Concrete sea-wall at Seaford, and the Harbour Company's wall, if united, now 1,400 yards apart, would save this coast for many years.

15. 'Beachy Head to Hastings,' by Colonel E. C. SIM, R.E., Brighton. Points out that sea-walls at Hastings, Bexhill, Eastbourne, Newhaven, Brighton, Worthing, &c., have arrested erosion of sea-coasts.

16. 'St. Leonards and Hastings,' by RICHARD B. GRANTHAM. Groynes, 120 to 200 feet long, locally protect the buildings and shore at the back of them.

18. 'Deal,' by Major A. C. HEPPER, R.E. At Walmer Castle an *increase* of shingle in a century. At Sandown Castle a decrease of 145 feet between 1741 and 1859.

19. 'Sheerness,' by Colonel LE MESURIER, R.E. The parish of Warden has lost 220 acres in 220 years.

20. 'Chatham and Sheerness,' by J. CHISHOLM GOODEN, Tavistock Square, London. Waste in the Medway estuary 157 feet in 14 years, at Sharpness 11 feet per annum.

To this Report is appended a 'Chronological List of Works on the Coast-Changes and Shore-Deposits of England and Wales,' by W. WHITAKER, B.A., F.G.S., of which 431 were received from the late Mr. Topley. They range from the year 1675 to 1886.

SECOND REPORT, 1886.[1]

Detailed Report.—1. 'Westgate to Margate, Kent,' by R. B. GRANTHAM, M.Inst.C.E., F.G.S. In places 20 feet of cliff has been lost between 1880 and 1886 ; a plan is given showing the area lost.

2. 'Estuary of the Colne,' by JOHN BATEMAN, Brightlingsea. Waste of 100 yards between 1832 and 1886.

3. 'The Deben to the Colne,' by P. S. BRUFF, M.Inst.C.E., Engineer to the Harwich Harbour Conservancy Board. Shingle diminishes where coast not protected by groynes. The coast is worn back on an average 50 feet in 10 years, but occasionally double that amount.

5. 'Aldeburgh to Cromer,' by W. TEASDELL, C.E., Yarmouth. Gorleston Cliff has retreated from 200 to 300 feet in the past 40 years.

6. 'Weybourn to Happisburgh,' by ALFRED C. SAVIN, Cromer. Shingle entirely diminishes through artificial abstraction. Cliffs eroded 2 yards a year when not protected by sea-walls.

7. 'Weybourn to Palling,' by CLEMENT REID, H.M. Geological Survey. Erosion about 2 yards a year. Groynes near Eccles have stopped this locally.

8. 'North-west Coast of Norfolk,' by J. S. VALENTINE, M.Inst.C.E., Westminster. Shingle taken where it accumulates, and where the coast is bare of it the cliffs have wasted back 20 to 30 feet in 40 years

[1] *Brit. Assoc. Report*, 1886, pp. 847–862.

9. 'The Coast of Pembrokeshire (Southern Part),' by KENNETH W. A. G. MCALPIN, Assoc.Inst.C.E., Pembroke Dock. No appreciable quantity of shingle is removed, no groynes occur, and the shingle does not travel; the rocky coasts are holding their own, and have reached the maximum of resistance, but traces of submerged forests at Newgale and Amroth point to former encroachments.

10. 'The Coast of Pembrokeshire (North-western Part),' by Captain THOMAS GRIFFITHS and H. WHITESIDE WILLIAMS, F.G.S. There are traces of submerged forests, pointing to subsidence, some trunks of which show traces of the axe.

THIRD REPORT, 1888.[1]

Memorandum C.—'Notes on the Coast-line from Penarth to Porth Cawl, in Glamorganshire,' by HORACE WOODWARD, F.G.S., Geological Survey. Material has travelled from the west, and owing to encroachments of the sea it has been heaped up on to old alluvial ground. The erosion of rock cliffs is not large.

Memorandum D.—'Notes on the Coast from the Wyre to the Ribble,' by A. DOWSON, C.E., Westminster. Great denudation takes place between Rossall Point and Blackpool, at the latter a sea-wall being twice destroyed. Considers sea-walls without groynes cause the shingle in front of them to be driven away, and solid groynes to cause dangerous scour, whilst open groynes, allowing the water to pass through, arrest the shingle and stop erosion.

Memorandum E.—'Notes on Coast of Durham between the Rivers Tyne and Wear,' by HUGH BRAMWELL, Whitburn Coal Company. At South Shields large quantities of sand are removed from just above ordinary and exceptional high tide marks for grinding sheet-glass; the sand is blown up and no appreciable waste of the coast takes place. The Tyne piers have absolutely stopped the travel of shingle from the north. Traces of submerged forests occur at Whitburn.

Memorandum F.—'Copies of seven Reports to the War Office and to other Government Departments on Various Parts of the South-Eastern Coasts (1856–1867),' communicated by J. B. REDMAN, M.Inst.C.E. Printed by permission of the War Department.

1. 'Sandown Castle.' In April 1857 the Secretary of State for War communicated to the Mayor of Deal to the effect that unless adjacent landowners to Sandown Castle joined with the Government in carrying out Mr. Redman's scheme for preserving that coast, the Castle would be dismantled and no further expenditure made on it. A copy of Mr. Redman's report was sent to the Mayor, the coast then being worn back more than 50 feet in four years, and he pointed out that at Walmer and the Admiralty premises at Deal the removal of shingle is strictly forbidden, and that this should be enforced along the length of the coast under consideration. This was afterwards done for the Deal frontage, but through no works being carried out as suggested, a recession of coast has taken place of 150 feet in six and a quarter years.

2. 'Sheerness Sea-Defences.' Report from Mr. Redman to Major Jervois, R.E. Refers to indiscriminate and injudicious removal of shingle and material at Cheney Point, at low water, as hurtful to all interested in the neighbouring foreshores, and even to the prospective advantage of

[1] *Brit. Assoc. Report*, 1888, pp. 898–933.

the owner, who, however, if this be a public injury, could be stopped in these operations through the Woods and Forests Department. In illustration, he refers to a recent case at the mouth of the Humber, where, by the indiscriminate removal of pebbles from Spurn Point for ballast and other purposes, a breach ensued which resulted in a very heavy expenditure, which might have been avoided had attention been drawn to the matter earlier.

3. 'Eastbourne Circular Redoubt Sea-Defences,' by Mr. Redman (1857) to Lieut.-Col. Owen, R.E. In 1805 the sea at high water was 120 feet seaward of the inside line of the counterscarp wall, or 250 feet from the centre of the redoubt; in 1808 the dimensions were 90 feet and 223 feet, showing a waste of 9 to 10 feet per annum. Surveys since that period show a rate of only half that amount, $4\frac{1}{2}$ feet per year for forty-nine years. Encroachment on this coast and the withdrawal of shingle are general on both sides of Beachy Head, and the defences of the Circular Redoubt have caused it to stand out as a point in front of the retreating coast-line, as was the case at Sandown.

4. 'Sandown Castle.' Report from Mr. Redman to the Secretary of State for War, 1860, showing that permanent works for the *isolated* defence of the Castle would cost 16,000*l*. Mr. Sidney Herbert (the then Secretary of State for War) determined to abandon the Castle; it was sold, and proved so tough a morsel that it was only lowered barely to the ground level. On the abutment of the drawbridge was the monogram of the great Cecil, Earl of Burleigh, Queen Elizabeth's Minister.

5. 'Dover, East-Cliff Shore. H.M. War Department and the Town Council of Dover.' Report from Mr. Redman to Lieut.-Colonel Jervois, R.E., Deputy-Inspector of Fortifications, 1863. Recommended joint treatment of the coast fronting Government and town property, 300 feet and 1,100 feet respectively.

6. 'Sheerness.' Report by Mr. Redman to Lieut.-Colonel Jervois, R.E., 1866. Recommends that where it is inevitable that shingle be taken for contractors' purposes for base of New Fort, it should be in short defined lengths, and that a new length be not commenced until the sea has begun to repair the damage.

7. 'Isle of Grain.' Report of Mr. Redman to the Secretary of State for War, 1867. From a plan of 1784 it appears the sea has gained on the land 700 feet to the north of the Isle of Grain Fort.

APPENDIX II.

INFORMATION RECEIVED AND COLLECTED SINCE 1888.

1.—*Report on Coast Erosion, East Kent,* 1895. By George Dowker, *F.G.S.*

Since the year 1884, when I reported on our coast erosion to the Committee of the British Association, I have made no minute survey of the coast, but having from time to time visited most part of the shores of East Kent, I have been able to note what has taken place during the ten years that have elapsed.

First, in Pegwell Bay, Isle of Thanet, there has been a continuous and large amount of erosion, not only from the sea having removed the talus of the cliff and the shore accumulations, but the cliff itself has been cut back at a rapid rate, more especially in the part where it is mostly composed of Thanet beds, at Cliff's End, Thanet. This latter station has very much altered during the last three years, nearly all the trees that fringed the top of the clay beds having been thrown down and washed away. And from the clay cliffs, the chalk to Pegwell and on to Ramsgate has witnessed many falls of more or less extent, and not only so, but all the talus is removed. There has been no attempt at erecting groynes or other defences along this part of the coast to stop the encroachments of the sea; but on the contrary there is going on a constant carting away of stones and sand.

At Ramsgate, both east and west of the harbour, there have been numerous falls of cliff, more especially after the winter; the cliff being for the most part perpendicular and devoid of beach or talus, the waves beat against the base of the cliff and bring down the material, loosened by rain and frost, by the concussion.

The exit from the harbour at low water has been much interfered with in consequence of the accumulation of sand bars at the entrance, and on several occasions during the winter the tug was unable to take out the lifeboat by reason of these sand banks. After a time the sand is swept round to the north side of the harbour and is subject to frequent changes, but in the main it continues to fill the recess made by the harbour wall much as it did in past years.

3. The river Stour has kept shifting its channel; in 1884 it was far removed from the point where it found an exit for its waters to the sea when the six-inch Ordnance map was made, and since then it has come closer in to the shore of Pegwell Bay; it has sand banks dry at each side of it at ordinary low tide, while a large expanse of shallow water is left between it and the shore, and the shifting in the mouth of the river may have had something to do with the rapid erosion of Pegwell Bay.

North of Ramsgate there have been numerous falls of cliff, more especially between there and Dumpton Gap; the current sets inward from the mouth of the harbour and impinges on the coast here. Round the north promontory of the Isle of Thanet the changes have not been so marked, but for the most part there is an absence of beach.

From Margate to Birchington the sweep of the currents has been from east to west; at Birchington Bay the groynes erected for defence have been swept away in some places, and the shingle swept clean out of them in others; near the Coastguard Station this is most apparent. An esplanade erected near the termination of the chalk cliff some few years ago seems rapidly being destroyed; it is situated just west of a promontory of chalk cliff at Lower Gore end in the new one-inch Ordnance map surveyed in 1892, and from this point to where the close groynes are erected at the Commissioners of Sewers' expenditure this erosion has been very rapid. At the latter place the sea-defences have been effectual in maintaining the sea-wall to Reculver; indeed, here the beach has somewhat accumulated of late, and I would remark that the drift direction of the beach has been uniformly from east to west.

Turning now to the coast to the south, outside the Isle of Thanet, I should observe that at Shellness Point the silting up by sand flats has caused an advance of the coast line since I last reported; but generally along the shore towards Sandown Castle I can perceive little alteration, and, indeed, although the authorities seemed to think the sea would speedily wash away all traces of the old castle, and so sold the materials that could be removed for building purposes, yet in spite of this the ruins remain, as far as I can see, just where they were ten years ago. Beach lines the shore here for a greater distance towards Pegwell Bay than formerly. At the north end of Deal, towards Sandown, the authorities have scarped the shore line and erected sea-defences by placing a timber foot to beach and groynes and formed a promenade walk on the top. This may have been effectual in protecting the shore, more especially as during the last two years we have had a prevalence of north and easterly winds. Through Deal to Walmer I can perceive but little change since my report in 1884. I did not at that time continue any detailed survey of the coast line beyond Walmer, but I reported generally, from cursory visits, on the shore to Dover.

To the north shore of Kent, between Reculver and Whitstable, I have made several visits since 1884. Between Reculver and Herne Bay the destruction of the cliffs has been rapid, chiefly between Bishopstone and Herne Bay, while on the front of Herne Bay itself there has been rather an accumulation of beach. At Whitstable the tide does not run strong in either direction, and it remains fairly stationary.

Between Whitstable and Sea Salter, to the west of the harbour, the beach has continued to collect in semicircular ridges that sweep round towards the shore, while opposite the Coastguard Station an old shore accumulation, which has been covered by vegetation, is being gradually washed away, and the sea is gaining on the land rapidly.

General Notes.—Walking along the coast from Lydden Spout to Dover last summer, in company with Captain McDakin, Mr. Webb, and Mr. Kerr, I could but notice the change that has come over this part of our shore line since I can remember it, and having had exceptional opportunities of many visits in connection with our East Kent Nat. Hist. Society dating back to the year 1858, in company with several eminent geologists, I have ventured to give my experiences of the changes that I can remember. Lydden Spout flowed out from the chalk in a small waterfall, starting from some considerable height (twenty feet above high-water mark) above the bottom of the cliff. The talus at that time consisted of old beach, covered with many rare wild flowers, and near to it was a series of steps in a stone stair leading to the top of the cliff. This was on the occasion of the visit of the members of the East Kent Nat. Hist. Society to Dover, when a large party of ladies and gentlemen, under the guidance of Mr. H. B. Mackeson, walked from Folkestone upper station to Copt Point, and thence to Lydden Spout. In reference to this I should observe that the shore at that time consisted chiefly of beach, and it would be exceedingly difficult for such a party of ladies and gentlemen to accomplish this journey on foot at the present time. First, the whole of a beach formerly met with at the bay near Copt Point, Folkestone, is entirely swept away; at the time I allude to it was of considerable extent, and partly cemented into a pudding stone by infiltration of water containing carbonate of lime. It was pointed out by Mr. Mackeson that at that time the extension of the western pier of Folkestone harbour had *deprived the fallen rocks of their supply and covering of shingle.* In the next place, many well-known spots in the undercliff (called the Warren) then in existence have long since been swept away. But what a contrast is presented by the shore at the present time! At Lydden Spout, where we halted the other day, the waterfall has disappeared among a huge mass of large fragments of fallen rocks, which jut out to sea and form a most serious barrier to the advance of the pedestrian along the shore. The stair to the top of the cliff has long since disappeared. Large and high boarded groynes erected to defend the shore are entirely empty of beach stones. The old platform of high beach on which we then botanised has all but disappeared, and the walk to Dover from the shore is a work of difficulty from the constant barriers of chalk blocks, which would of themselves form a trap for the beach, as they had done in former years, had there been any beach to travel. It appears to me that much of the fall of cliff and erosion of coast has been brought about by the sea having removed all the beach to the west of Dover and disposed of much of it between Shakespeare's Cliff and the Admiralty Pier, while no fresh beach has arrived from the westward to take its place.

Just in Dover Bay the beach seems to ebb and flow inward and outward; but in the long run there seems more abstracted than replaced, and eastward of the harbour the sea has swept away all the beach towards the South Foreland, and many falls of cliff have taken place.

In conclusion, in my report made in 1884 I gave it as my opinion that the beach was carried in the direction of the *prevailing currents*, and not, as is generally stated, by the *prevailing winds*. In a note I received from the late Mr. W. Topley I was informed that this view was not held by Mr. Redman, nor by any of those contributing reports. But during the last ten years I have met with no facts that in the least tend to throw doubts upon the view I then expressed. The prevalence of north and east winds does check the advance of the beach in that direction, and when gales occur from that quarter accompanied by high tides the shifting beaches and sands are thrown back in places; but the effects are small compared with the carrying power of the flood tide. Off Dover and Ramsgate the force of the flood tide greatly exceeds that of ebb. This is shown in some observations made by E. K. Calver, Surveyor Master R.N., addressed to the Hydrographer of the Admiralty in January 1863, with accompanying tables then given, and published as correspondence between the Society of Antiquaries and the Admiralty in reference to Cæsar's landing-place.

It is to be noted that the beach has been travelling from south to north between the North and South Forelands, while at the north of Kent, between Margate and Whitstable, it travels exactly in the opposite direction.

During the last two years there has been a preponderance of winds from the north and east as compared with those from the south and west, and we should have expected a corresponding change in the sea coast. This has not been the case off Ramsgate. The sands from the Sandwich flats are constantly driven towards Ramsgate, and they are carried by the flood tide north of the harbour, where they constitute the Ramsgate sands. During the north-easterly gales they were retarded in their northward course and formed bars in front of the harbour; this, I am informed by the harbour master, has happened again and again; but these bars are removed again by the natural flow of the tide to the north. North-easterly gales setting in shore here have probably had much to do with the excessive erosion in Pegwell Bay and in causing a deflection in the river's mouth.

There appears to have been a constant similar motion in the direction of the beach at Whitstable, this town being built upon a series of beaches in parallel succession and curving towards the sea. At the present time this is going on south of the town towards Sea Salter. Deal, on the other hand, is built on a series of beaches that run parallel to the shore. At the latter place the first formed beach seems to have been at a lower level, and at the north end of Deal cuts off the sea from the low marshy flat behind. When the gasometer was put down some years ago, it was found this marshy peaty soil was of considerable depth. The sand-hills likewise cover some old beach.

My visits to New Romney and Lydd beach have been few and far between, but on the last occasion, some five years ago, I visited Lydd, New Romney, and Dymchurch, the beach at Dungeness was still advancing, and the ridges of shingle making semicircular curves; while at Romney and Dymchurch the sea was attacking the land.

Why the beach should so accumulate at Dungeness is not apparent, nor would prevailing winds account for it; it is certain that the beach travelling towards the north-eastern shores is arrested to its detriment. I believe we must look for some other cause than the winds, such as a change in the velocity or direction of the flood tide. It is evident from historical data that a beach formerly existed between New Romney and Hythe that protected the shore at Dymchurch. The remnant of this beach is apparent in the neighbourhood of Hythe, the falls of which are figured in Mr. Drew's Memoir on the Geology of Romney Marsh, surveyed in 1860.[1] Mr. Drew has quoted some ancient charters, notably that of King Egbert, A.D. 833, which had been brought to his notice by Canon Jenkins and Mr. Mackeson in favour of a notion they entertained with respect to the ancient river Lienen, which they supposed washed the base of the Lynn Roman Castrum. But it will be seen that if the place called *Sartum* in this charter is to be identified with the place now called Sandton, between West Hythe and Butler's Bridge, the charter quite contradicts their inference with regard to the River Lienen, which places the river south of that place, not on the north of it, as the Castrum now stands. It will be seen in reference to the Geological Survey Map of Romney Marsh that the ridges of shingle lines which tend inwards towards Hythe and West Hythe from Dymchurch Redoubt are but the remains of a much larger gathering of shingle which must have existed here, and in Roman times had defended the Dymchurch marshes from inundation.

2.—*List of Stones from Dungeness. Collected by* Rev. F. GELL *when at Lydd (now Rector of Edburton, Sussex). Examined in Geological Survey Office*, February 23, 1889.

General Remarks.—Many of the stones are from the Wealden beds, probably of the Sussex coast.

Two may be from the Budleigh Salterton Pebble bed (6 and 43).

One is very like Cornish Elvan (7*); four others may possibly be Cornish Elvans (9,* 15,* 18,* 27*). The general aspect, however, of the igneous rocks is not such as one would expect in Cornish rocks.

Foreign pebbles from other parts of the Southern Coast (and also those in the 'Drift' at Selsea) have been referred to the rocks of Brittany, &c., and such may also have been the origin of them.

It must always, however, be remembered that ballast may be thrown out of ships at the ports along the coast, and also that ships travelling in ballast only may be wrecked, and their contents be thrown up on the beach.

[1] See *Memoir on Romney Marsh*, p. 20.

List No. 1.

1. Doubtful.
2. Sandy ironstone.
3. Sandy ironstone.
4. Greenstone.
5. Cherty sandstone. ? from the Greensand.
6. Quartzite pebble. Such as from Budleigh Salterton.
7. Clay ironstone. Possibly Wealden.
8. Sandstone.
9. Doubtful.
10. Hard ferruginous sandstone, 'Carstone.' ? from Lower Greensand.
11. Greenstone.
12. Doubtful.
13. Sandstone.
14. Chert, with sponge-spicules. ? Greensand.
15. Doubtful.
16. Syenite.
17. Hard sandy ironstone or ferruginous sandstone. (? may be Wealden.)
18. Doubtful.
19. ? Micaceous sandstone.
20. Hard coarse grit.
21. Ferruginous sandstone.
22. Syenitic granite.
23. ? Sandstone.
24. Ferruginous sandstone. ? from lower part of Hastings cliff (Fairlee clay.)
25. Sandy ironstone.
26. Pale grit. From Wealden beds.
27. Sandstone.
28. Hard quartzose sandstone.
29. Indurated shale.
30. ? Decomposed igneous rock.
31. *Endogenetic erosa.* From Wealden beds.
32. Sandstone.
33. Calcareous grit. ? Wealden beds.
34. Felsite (?)
35. ? Sandstone.
36. Quartzite.
37. Greenstone.
38. Sandstone.
39. Doubtful.
40. Sandy ironstone. ? Wealden.
41. ? Chalk flint, full of sponge-spicules.
42. Chalk flint.
43. Quartzite. ? a Budleigh Salterton pebble.
44. ? ?
45. ? ?
46. Chert.
47. ? ?
48. Syenitic granite.
49. Ferruginous sandstone.

50 to 65. Doubtful.

A. Sandstone.
B. Sandy ironstone, probably Wealden.
C. Hard sandstone.
D. Ferruginous sandstone.
E. Sandstone. ? Wealden.
F. Sandstone. ? Wealden.

List No. 2, *marked with Red* *

1. Grit.
2. Porphyritic felsite, or ? porphyrite.
3. Felsite (?)
4. Grit (fine grained).
5. ? hornstone.
6. Probably an artificial slag.
7. Quartz porphyry, very like a Cornish elvan.
8. *Endogenetic erosa*, probably from the Wealden beds of the Hastings cliffs.
9. Porphyritic felsite (? same rock as 18*). May possibly be a Cornish elvan.
10. Syenite.
11. Syenite.
12. ? hornstone.
13. Syenitic granite.
14. *Ventriculite* in flint.
15. Porphyritic felsite. May possibly be a Cornish elvan.
16. ? ?
17. Syenite.
18. Porphyritic felsite (? same rock as 9*). May possibly be a Cornish elvan.
19. Granite.
20. ? ?
21. ? ?
22. ? peculiar rock, not known. Might hereafter be useful for comparison.
23. ? ?
24. Probably an artificial slag.
25. Hornblende porphyry.
26. Quartz rock.
27. Porphyritic felsite. May possibly be a Cornish elvan.
28. ? Hornstone.
29. ? ?
30. Sandstone, micaceous.
31. Syenite.
32. ? ?

A. Calcite vein in ? hornstone.

3.—*Shingle Beaches. Copy of Report from* Commander DAVID PEAR, *R.N., Inspecting Commander, Folkestone District, to the Harbour Department, Admiralty. October* 9, 1844.[1]

1. The extent of shingle beach in the Folkestone district from Dover Castle to the mouth of Rye Harbour is 35 miles. The general direction is E.N.E. and W.S.W., but on the west side of Dungeness the coast lies S.E. and N.W., and is the most exposed part of this district.

2. S.W. winds are those which bring the shingle. Moderate breezes heap it up the most, and heavy gales at spring tides often form a number of small 'fulls' into one.

3. It appears to come from the westward. Arises from the wearing away of the cliffs, and travels along shore.

4. From the westward of Beachy Head. The pebbles, to my personal knowledge, bear the same appearance from Dover, as far as the headland mentioned, only they are larger at Eastbourne and Langley Fort, where churches, houses, and walls are built of them.

5. Gales from whatever direction, accompanied with a heavy sea, scour the beach; but it depends on the angle at which the sea strikes the beach whether the shingle is carried onward, and a heavy sea brings down towards low-water mark many of the small 'fulls' formed in smooth weather.

6. It loses from Rye Harbour to Dungeness Point, gains from Dungeness Point to near Dymchurch, and loses from Dymchurch to past Dover Castle.

7. A strip of land or rocks extends from the foot of the shingle to low water. The tide from Rye Harbour to Dover leaves the shingle generally at three-fourths ebb, except for two miles on each side of Dungeness Point. No bed of shingle has been found under the sand, but stones are mixed with the same.

8. A gale, followed by moderate weather, often brings up the shingle from the lower to the upper part of the beach in a single tide to the thickness of 3 or 4 feet.

9. The size of the shingle on Dungeness is from that of a man's fist to small gravel; the large ones increase along the coast west to Beachy Head, and are smaller at Dover than at Dungeness. The weight, large packed with small, is one hundred and fifteen pounds per cubic foot.

10. Yes, variations exist; the cause, abrasion in passing along the coast.

11. The shingle generally along the shore is only a narrow ridge, extending from high to near low water; but there are at places large deposits from Beachy Head to Dover—viz. Langley Fort near Eastbourne, Pett Level, Dungeness, and Hythe Bay. The average thickness may be reckoned 20 feet, and their extent in all 25 square miles. At Dungeness Point report states 70 feet as the thickness.

12. The greatest increase is at Dungeness Point, which is 6 feet annually.

13. Cannot say respecting the Cornish bays, but in my opinion shingle passes round headlands, across flats, and even crosses the mouths of rivers where they join the sea.

[1] The numbers given refer to a schedule of questions, evidently by the Harbour Department in 1844, and have no reference to those used by this Committee.

14. The shingle moves westerly with gales from the eastward, and *vice versâ*; the wind and gales being more frequent from west or south-west than east makes the shingle travel in an easterly direction.

15. The distance of the ridges at Dungeness are, where most regular, about 25 yards, and also at Hythe and Langley Point; from Dungeness to the green fields in Denge Marsh is upwards of 2 miles. There is a ridge extending from Dungeness east to Great Stone Point, formed in a gale that occurred in November 1842, and from other small 'fulls' forming outside of it, I do not think any future gale will obliterate it.

16. The general angle from the top of the 'full' at spring tides to where the shingle meets the sand is about 20°; but in smooth water, close to the 'fulls,' the shingle often lies for 10 or 12 feet at an angle of 45°.

17. Cannot state.

18. None to my knowledge.

19. The groynes from Dover to Beachy Head are all put down at right angles with the shore. I cannot suggest a better direction.

20. The longer and the higher the groyne the more shingle will it retain; the longest and most efficient I know is that under East Cliff at Hastings, which protects that town as far as the fish market; its length must be about 150 yards, and whilst the west side is of shingle, the east side shows a vacant depth of 14 feet. The new harbour at Folkestone may be considered as a groyne, as the ground on which part of a large hotel and the harbour house now stand were, to my knowledge, in 1820 overflowed every tide.

4.—*Notes on the Waste at Sheppey, by* Professor THOMAS MCKENNY HUGHES, *in 'Geology of the London Basin.'* [1]

'In Sheppey the most rapid waste appears to have occurred near Warden Point, where within the memory of man the sea is said to have cut back the cliff between 200 and 300 yards. An old soldier informed me that he distinctly recollected that the year after the battle of Waterloo there were houses standing as far from the church on the north-east as those then built along the road to the west of it. I measured the distance pointed out by him, and found it to be 220 yards.'

'All along the cliff as far as Lane End Coastguard Station the older inhabitants tell of farm-buildings which they recollect standing on ground long since swept away, with perhaps 200 feet of cliff below it. It would be idle to speculate on the average rate of waste along the whole north coast of the island with such insufficient data, but we may well suppose that even when Lord Shorland swam his horse out to the Nore the distance was perceptibly less than now.'

'When a storm blows from the north or east a very heavy sea lashes the north coast of Sheppey. The fallen clay and sand is removed from the base of the cliff, and shingle heaped up along the low shore to the west. Fresh slips in time occur, and so the whole cliff is being eaten back very rapidly.'

'The manner in which this goes on is as follows:—In the hot weather the surface of the ground is cracked from the shrinking of the clay, and the cracks are seen along the highest ground as gaping fissures, about

[1] *Memoirs of the Geological Survey*, by W. Whitaker, 1872, p. 387.

6 inches across and many yards in length and depth. When the rain falls it finds its way into these, and softens the clay at the bottom. If the crack is near the cliff, the half-detached mass being now heavier, owing to the addition of the water, while the cohesion of the attached portion is lessened, slips down to the shore below, sometimes almost unbroken, sometimes breaking off by parallel cracks into a series of terraces, or even in part creeping down among the fallen stiffer masses as a glacier-like mud flow. Fine examples of slickenside are seen behind the slips. The sea washes this débris away from the base of the cliff, and the process is repeated.'

5.—*An Account of Dunwich in* 1589.[1] *By* RADULPH AGAS.

'The Toune of *Dunwich*, a Coaste Toune, neare the Midle of the Sheire, is scituate upon a Cliffe fortie Foot hie, or there about ; bounded on the Easte with the Otian Sea ; on the Weaste with the Toune of *Westleton*, and is girt on the Weaste and South, neare to the bodie of the Toune, with an Auntient Bancke, whereof Parte is now builte with the Wall of the *Graieffriers* ; the North and Southe ends are environed with diverse Marishes, Shredds, and divided with Fleetes, Crickes, and Diches ; the Auntient *Haven* there was somtime at the North Ende of the Toune, where standeth now their *Keie*, which Haven was utterlie choaked upp, with a North-Easte Winde, the foretene Daie of *Januarie*, Anno 1 *Edward* III. notwithstanding if it were recovered woulde not onlie preserve the Toune from Danger of the Sea; but bie Helpe of a *Sluce* weasteward, woulde be soe mainetained the same as might likelie bringe the same Toune neare to her former estate and condition. At the Losse of this Haven, another was opened verie neare the Place, where *Dunwich* Men have, now in a shorte time, bie Helpe of Nature, prepared a Passage as by ancient Inquisit, and other evidence maie plainelie appeare, *videlez*, fere duas leucas ab antiquo Portu : That this Haven hath been offtentimes chaunged ; for the whole Raunge of Shingle assureth it in noe Place certaine, causing it to runne Southward bie trussing, and choakinge the same with Beach, appeareth bie sondrie evidence, videlez. that the Men of *Bliborough*, *Walberswick*, and *Southwold*, shall paie duelye to *Dunwich* men their Toules and customes, ubicunq; portus ille mutari contigerit. That as novi portus ac filum aquæ ejusdem shall be the Boundes betwene the Toune of *Dunwich*, and the Lordship of *Bliborough*, ubicunq; dictum novum portum in futurum diverti vel mutari per jactum sabuli vel aliunde contigerit ; as also bie the view of the Place itselfe. Notwithstandinge were it now runneth these have bie good happe lighted on an owse Banke, at the South Side of the Haven, which causeth the back Water to turne of the Beache, and to lie straight againe the Mouthe, as hath happened divers times since the same was opened first. And although the North Easte Windes have been, since the same was opened, most violent and extreme, as also the 10, 11, 12, and 13 of this present Moneth, yet the verie nexte Daie affter, being the fourteenth Daie, divers loaden crayers went readilie out of the same. And whereas there are now to Flattes, on the North Side of this Haven, which the *Walberswick* and *Southwold* Men

[1] Quoted from 'An Historical Account of Dunwich, anciently a City, now a borough; Blithburgh, formerly a Town of note, now a Village; Southwold, once a Village, now a Town-corporate; with Remarks on some Places contiguous thereto.' By Thomas Gardner: London, 1754 (British Museum pressmark 189 *a* 17).

would willinglie turne *Dunwich* men unto ; being notwithstandinge Owners, under her Majestie, of the same Haven there, and more than a Mile above, and the intended Cuttes of the said *Walberswick* and *Southwold* men there, very dangerous to all Passengers, bie Reason of certaine Flattes caled *Passelie Sands*, yf a Cutt were made both on a Levell, and as appeareth Owessey Ground, from the Weaste Flatt toward their keies, they should remedie those Flattes, and perfect the Haven as bie this Platte may better appear.'

6.—*First Report addressed to the Committee on the Erosion of Dover Cliffs,* 1891–92. *By* Captain S. GORDON McDAKIN.[1]

The cliffs are composed of chalk, and reach an elevation of 526 feet on the west near Folkestone, and 400 feet at the South Foreland, and extend for about six miles on each side of Dover. The coast has been compared with the 6-inch Ordnance map of 1876. Marks at about a height of 2 feet from the shingle or plane of marine erosion have been placed in situations attacked by the sea. These consist of half-inch holes, three inches deep, plugged with wooden pegs, and were disposed in a triangle for 1890, perpendicularly for 1891, and horizontally for 1892, the middle being the test-hole, the others only indicating their position to the eye. Such holes are less liable to be tampered with than other marks, and could not be counterfeited with the means likely to be at the disposal of anyone mischievously inclined.

The results have been recorded, and an extract is appended, from which it appears that at the Cornhill, about two miles east of Dover, the erosion is not more than half an inch in twelve months, and in the hard nodular chalk almost imperceptible

The same applies to St. Margaret's Bay.

To the west of Dover the cliffs have suffered to a greater extent.

From Shakespeare Cliff to the Channel Tunnel works, about a mile, the undercliff formed of old slips has been attacked and largely removed this winter (1891–1892).

From the Folkestone cliffs, five miles west of Dover, the triangular marks have disappeared. This part of the coast consists principally of undercliff, formed by the ancient slips. The rock here is saturated with fresh water, and the severe frosts of 1890, 1891, and 1892 have attacked the surface to a depth of more than eighteen inches.

Looking at a map it will be seen that the coast recedes west of Dover. This is due to two causes ; the *minor* cause, the soft grey chalk which is here at the sea level, and the *major* cause, the springs which issue out at the base of the cliffs, either over the surface of the Gault or that of the impervious Lower Chalk, and so undermine the cliffs. Sudden falls of thousands of tons forming an undercliff, which in its turn is removed by the sea.

A great translation of shingle has taken place during the last ten years from the Folkestone cliffs towards the Admiralty Pier at Dover. The numerous wooden groynes in front of the South-Eastern Station are now buried under the shingle.

[1] East Kent Natural History Society and Dover Natural History Society.

In a similar manner the shingle carried from the front of the houses known as the East Cliff some years previously was not replaced by shingle from the west, owing to the Admiralty Pier intercepting it. This is also the case still farther to the east, where a tunnel was made, about twenty-two years ago, for the footpath that had been destroyed through the protecting shingle beach having travelled eastwards, and not having been replaced by fresh shingle from the westward. On February 23, 1891, an extensive fall of chalk took place from the cliff above Crab Bay, about 300 yards east of the Cornhill Coastguard Station. At one o'clock the same day a small quantity of chalk fell, and at five o'clock a huge mass slid from the top of the cliff with a thundering noise like the report of an explosion, the earthquake-like shock being felt in the Coastguard houses. The cliff at this place is 320 feet high. This fall was reported in the 'Dover Standard' of the same date. I passed along this cliff at four o'clock, or scarcely an hour before the fall, which was distinctly heard by a gentleman walking on the Admiralty Pier at Dover, two miles and a half distant. I noticed fissures on the top, from seven feet wide to a few inches, running S.E. fifty-five yards, and thirty yards in length, then one parallel to the edge of the cliff for sixty-two yards, and three others, forty-five yards, forty-one yards, and about thirty yards, running S.W. from the parallel fissure to the edge of the cliff. For the whole distance of 330 yards from the Coastguard Station eastwards there is evidence of a subsidence and many minor cracks or fissures.

This fall occurred in calm weather, the winter having been remarkably free from storms and the weather dry. There had, however, been a great deal of snow about the middle of the previous month, with intense frost, the ground having been frozen to a depth of eighteen inches.

Still farther to the east at St. Margaret's Bay, about four miles and a half from Dover, the chalk on the sea line was without perceptible erosion. One part of the south cliff overhangs in a most threatening manner.

The marks are ½ in. holes 3 in. deep, drilled in chalk.

—	Marks for— 1890	1891	1892
East of Dover (about 1½ mile): Cornhill Stairs.			
1. White soft chalk. S. G., 1·92. Absorption 15·36, per cent.	Erosion in 12 months, ⅛ inch	About 1½ in. in 2 years	...
2. Same bed as No. 1 . .	Erosion, ½ in. in 12 months	Eroded 3 in. in 2 years	"
3. Same bed as No. 1 . .	Erosion, ½ in. in 5 months, covered by fall of cliff in 12 months	Covered by fall of cliff.	"
4. Large mass of nodular chalk slipped from above. S. G., 2·25. Absorption, 15·94 per cent.	Intact in 12 months.	About 3 in. in 2 years	"
5. Same bed as No. 1 . .	Erosion, ⅛ in. in 12 months	Erosion, 1½ in. in 2 years	"
6. Same bed as No. 1 . .	Intact in 12 months.	1½ in. in 2 years .	"

The marks are ½ in. holes 3 in. deep, drilled in chalk.

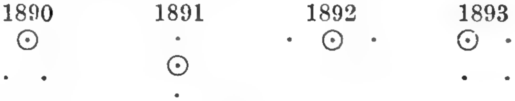
—	Marks for— 1890	1891	1892
West Cliff, Dover: Shakespeare Cliff.			
1. In a hard nodular block detached from cliff	A storm overturned this in 5 months	Split through and broken up	,,
2. In grey chalk . . .	Eroded ⅛ in. in 5 months	Obscured by shingle	,,
3. In grey chalk. S. G., 2·27. Absorption, 7·82 per cent.	Erosion, ½ in. in 5 months	Disappeared in 12 months	,,
4. Large detached block, exposed at all tides, hard nodular chalk. S. G., 2·25. Absorption, 15·94 per cent.	Erosion, ¾ in. in 12 months	Obscured by movements of shingle	,,
5. Grey chalk. S. G., 2·27. Absorption, 7·82 per cent.	Intact . . .	Intact . . .	,,
6. Exposed to full action of sea at all sides	Disappeared in 12 months	Disappeared . .	,,
Folkestone Cliffs.			
1. Hard *Mæandrina* chalk forming part of undercliff, 5 miles west of Dover	Disappeared in 12 months	Cliff falling . .	,,
2. Grey chalk . . .	Disappeared in 12 months	—	,,
3. Yellow soft chalk . .	Disappeared in 12 months	—	,,
4. Same bed as No. 3 . .	Lost 1 in. in 12 months	Disappeared . .	,,
5. Same bed as No. 3 . .	Lost 1 in. in 12 months	—	,,
6. Hard, nodular chalk, exposed at every tide	Lost ¼ in. in 12 months	Disappeared . .	,,
St. Margaret's Cliff (four miles east of Dover): South side of Bay.			
1. Grey white bed. S. G., 1·94. Absorption, 22·4 per cent.	Intact in 12 months.	Lost 1 in. in 2 years	,,
2. Same bed as No. 1 . .	Intact in 12 months.	Intact, but the shingle fallen 6 ft.	,,
3. Same bed as No. 1 . .	Intact in 12 months.	Shingle also moved.	,,
North side of Bay.			
1. This station only reached by storm waves. White bed. S. G., 1·94. Absorption, 18·4 per cent.	Intact in 2 years .	—	,,
2. Same bed as No. 1 . .	Intact in 2 years .	—	,,
3. Same bed as No. 1 . .	Intact in 2 years .	—	,,

7.—*Second and Concluding Report on the Erosion of Dover Cliffs, from St. Margaret's Bay to Folkestone, a distance of about eleven miles, addressed to the Committee, May* 1893. *By* Captain S. GORDON McDAKIN.

The cliffs, composed of chalk, reach an elevation of 525 feet on the west at Folkestone, and 400 feet to the east of Dover, to about 200 on the south side of St. Margaret's Bay; the High Light, South Foreland, 374 feet; and 88 to the north of St. Margaret's Bay.

The coast has been compared with the 6-inch Ordnance map of 1876, and marked at twenty-four principal stations and eleven intermediate ones with marks at about 2 feet above the shingle on plane of marine erosion: these marks are bore-holes 3 inches deep by ½ inch wide. This form was chosen as not so likely to be tampered with as other marks, and because they would be difficult to imitate without a special tool. Each year has a different mark.

1890 1891 1892 1893



The hole with the circle drawn round it is the test-hole, the others are only indicating marks.

As in the former reports for 1890–1891, the changes are rather those of the undercliff than the cliffs themselves; this applies especially to the Folkestone Cliffs and West Cliffs, Dover.

In last year's report the foretold likelihood of a slip has been confirmed by a tremendous fall from the Abbot's Cliff, which is here 450 feet in height, amounting to many thousands of tons.

To the east of Dover (Cornhill) stations Nos. 5 and 6 in soft white chalk have lost half an inch in twelve months. Stations 1, 2, 3, and 4, in harder beds, particularly that of No. 4, in very hard nodular chalk, exhibit little or no erosion.

West Cliffs, Dover.—The sea has here attacked the undercliff and talus. The marks 1, 2, 3, 4, on large detached block, have disappeared by the block having been overturned, displaced, or buried, the actual erosion of the surface not amounting, on an average, to more than about half an inch in twelve months in exposed situations, and washed by every tide. At No. 6, a large detached mass, the marks of last year (1892) are intact on two faces.

Folkestone Cliffs.—Great inroads have been made on the undercliff of the Warren in three years. The mark at Station No. 1, lost sight of last year, was found again, even the mark .·. of 1890 being intact, although 2 and 3 have disappeared. At No. 4 last year's mark (. . . 1892) also was intact, but 5 and 6 are lost or covered by falls of the cliff.

St. Margaret's Bay, four miles east of Dover.—South side of bay, mark at Station No. 1 disappeared. Stations 2 and 3 intact, but a soft band of chalk close to beach is here very much undercut by the sea, so that large masses may be expected to fall. North side of bay, mark at Station 1 of last year (. . . 1892) had been tampered with, an attempt having been made to cut it out; but taking the general surface and depth of hole, the marine erosion was imperceptible. Stations 2 and 3, only reached by storm-waves, were intact. The cliffs are here quite perpendicular, and about 88 feet in height. Since the 6-inch Ordnance map of 1876 was published there has been no great loss of land, but several heavy falls of cliff, amounting to some thousands of tons, as at the Cornhill Coastguard Station, two miles east of Dover, on February 23, 1891, and the still larger one at the Abbot's Cliff Coastguard Station (Lydden Spout) early in the present year.

The recession of the coast line westwards from Dover to Folkestone is no doubt caused by the uncertain foundation of underlying Gault clay, which retains the water passing through the porous chalk, the sea carrying away the *débris*: this is particularly the case where groynes or piers at right angles to the shore have intercepted the shingle coming from the west, that to the eastward of such obstructions gradually passing away in that direction, and not being replaced by fresh accretions from the west. The shore, being undefended by the shingle beach, is exposed to wave-action.

The Folkestone pier intercepts the shingle that at one time defended East Wear Bay, the Folkestone Cliffs, and the West Cliffs, Dover. The Admiralty Pier, Dover, has in like manner robbed the foreshores of the Esplanade, Dover, and the East Cliff, Dover, of their shingle, making costly revêtements and sea-walls necessary.

APPENDIX III.

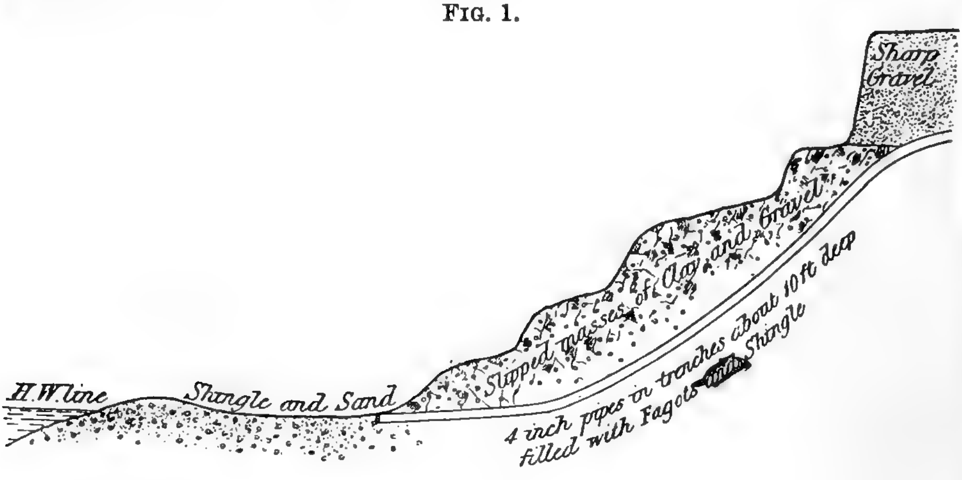
VARIOUS SCHEDULED RETURNS: REPLIES TO PRINTED QUERIES CIRCULATED BY THE COMMITTEE.

Hampshire Coast.

By Richard F. Grantham, M.Inst.C.E.

1. Part of the coast of Hampshire, east of Christchurch, opposite Highcliffe, and the village of Newtown.
2. a. Cliffs composed generally of a bed of sharp gravel, varying from 13 to 18 feet in thickness, overlying the slippery Barton clay. **b.** 80 to 100 feet.
3. Nearly east and west.
4. South-west.
5. South-west.
6. Flood tide eastwards, ebb westwards, generally.
7. Five feet in Christchurch Bay.
8. Shingle and sand.

Fig. 1.



9. a. I have not had an opportunity of measuring this. **d.** From 3 to 4 inches.

10. I should say stationary.

13. The degradation of the cliffs is due to the water issuing from the base of the gravel over the slippery clay surface.

14. The face of the cliff has slipped away at a rate of 3 feet per annum, taking an average line of about $\frac{3}{4}$ mile in length during the last twenty-two years. This is the rate as ascertained during that period, and it is probable that this has been the average rate for a longer period.

The shingle beach appeared to me to be stationary; so now that drains have been laid up the slipped slopes of the cliff to remove the water issuing between the gravel and clay, the slopes will become consolidated, and slipping will no longer take place.

15. It must be explained that the course of the channel of the river Avon formerly ran parallel to the beach eastwards for some distance from its mouth in Christchurch Harbour, but certain works executed some time ago by some landowner at the mouth had the effect of diverting the course straight out to sea, and thus the channel parallel to the beach has become stopped. No doubt this is the cause of the present stationary character of the beach, for otherwise erosion would take place, and the slipping of the cliff further facilitated by the undermining of the toe.

16. No.

17. No.

Sussex Coast.

By Richard F. Grantham, M.Inst.C.E.

(1) *Opposite Lancing.*

1. Sussex coast, opposite Lancing. It is that portion which lies between 'Shop's Dam' and the gap in the Worthing and Lancing Road, referred to in my father's returns, Nos. 11 and 12 in the Committee's Report, dated 1885.

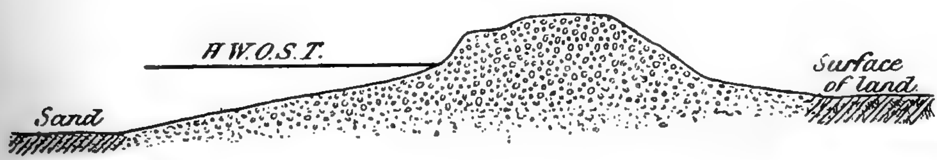
2. The main features of that part of the coast are described in those returns, but I have, within the last two years, constructed nine groynes between Shop's Dam and the gap in the road, a distance of about 1,100 yards.

3. That is westwards of the groynes erected under my father's superintendence; but I have had an opportunity of making a survey of that part of the coast, which shows exactly the rate at which the sea has been advancing opposite Lancing.

8. Partly of shingle, partly of sand foreshore. Opposite the Coastguard Station, west end of Lancing, chalk rocks and flints, covered with seaweed, can be seen at low water slightly above the level of the sand foreshore. In storms the flints are loosened, raised up, and washed up on the shore.

9. The shingle lies in the form of a high bank, thus:

Fig. 2.



The base of the shingle bank is about 500 feet broad, and the top of it is about 6 feet above H.W.O.S.T.; the land behind is below the level of H.W. Formerly, in storms, the sea washed the shingle back, encroaching further and further on the low-lying land. There is a 'fall' of shingle, but this varies according to the state of the sea. It is generally just above H.W. springs.

11. I think that until the groynes were erected the quantity of shingle remained constant, but it was perpetually being driven back.

12. a, b, and **c.** The new groynes point south-east at a rather greater inclination with the shore line than those erected by my father. Their length is 300 feet, and the width apart is 400 feet, except the three groynes at the west end, which are 350 feet in length and rather closer together. **d.** The top end is 18 feet above O.D. and 8 feet above H.W.O.S.T. **e.** Timber partly memel, partly beech. **f.** Although they are not yet planked up, and although there has been an unusual number of heavy gales during the past winter, 1893–94, they have completely arrested the encroachment of the sea, so that no damage has been done, nor has any shingle been swept back over the bank. The groynes will be planked up in time as the shingle and sand accumulate.

13. a. No. **d.** No.

14. Before the groynes were erected the sea had washed the shingle back, so that opposite the Coastguard Station at Lancing the high-water mark was at the date of my survey (1891) 320 feet further inland; and at a distance of 160 yards west of Shop's Dam, 70 feet further inland than it was at the date of the Ordnance Survey (1875).

15. The influence of the new groynes in accumulating shingle had at first a slightly deteriorating effect on the accumulation at the groynes my father erected, but the gales of the past winter have brought up an immense quantity of shingle, and those groynes are now filled again.

16. No.

17. No.

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(2) *Between Selsea Bill and Chichester Harbour.*

1. Sussex coast, between Selsea Bill and Chichester Harbour.

2. Low cliff, varying from 4 to 11 feet above high water ordinary spring tides. The cliff is composed of loamy clay mostly, but at the west end of the bay there is gravel and sand about 4 feet below the surface. Clay appears on the shore at low water.

3. North-west to south-east.

4. South-west.

5. South-west. When the wind is westerly or south-west the shingle travels from about $\frac{3}{4}$ mile east of Chichester Harbour eastwards to Selsea Bill, and from the $\frac{3}{4}$ mile east of Chichester Harbour westwards. When the wind is easterly the shingle travels westwards from about 2 miles east of Chichester Harbour.

6. Flood tide eastwards; ebb tide westwards.

7. (1) **a.** 16 feet 6 inches; **b.** 12 feet 6 inches. (2) Probably about 9 or 10 chains; say 200 yards at springs, more at very low springs.

8. Sand mostly. There is some mud near the cliff, opposite Bracklesham Farm. Shingle lies up against the foot of the cliff all the way.

9. a. Varies from 15 yards east to 24 yards west at ordinary seasons, but these would vary in different seasons. **b.** High water, spring tides, does not quite cover it. **c.** I have stated this in answer to Question 5. **d.** About 9 inches across every way. **e.** The shingle formed one continuous slope when I saw it, and I should not think this varied.

10. I should say the quantity of shingle was generally maintained, the quantity depending on different seasons.

11. Some has been taken away for repairs of parish roads; but this is only a small quantity, and the removal is now stopped.

12. A weak form of groyne has been tried both at Thorney Farm and at Cockham Manor. The piles at the former are still standing, but those opposite Cockham have disappeared. They were evidently weak, and required so much repair that they were abandoned. **a.** At right angles to the shore. **b.** and **c.** They appeared about 100 feet long, and from 80 to 100 feet apart. **e.** Beech timber.

13. a. From the end of Bracklesham Lane, and from the end of Cockbush Lane. **b.** and **c.** Repair of parish roads by the waywardens. **d.** I should say not.

14. All the way along, at a considerable rate. **a.** From 6 to 8 feet per annum opposite Bracklesham Farm; about 8 feet between Bracklesham Farm and Cockham Manor Farm. **b.** 10 to 13 feet opposite Cockham Manor Farm. **c.** During the winter 1891–92 the rate must have been from 15 to 20 feet opposite Cockham Manor Farm, from the appearance of the remains of parts of the cliff. **d.** These measurements agree with a comparison of the 1-inch Ordnance map, surveyed in 1805, and the 6-inch Ordnance map, surveyed in 1873.

15. There is nothing along this line of coast to cause an accumulation of shingle, so what is there is deposited and left to be carried on or taken away by the sea.

There is, however, an increasing accumulation of shingle on the east side of Selsea Bill, but I have not had an opportunity of examining this.

16. None.

17. No.

19. I should add that from opposite Marsh Farm to Thorney Farm there is low-lying land below the level of high water. This is partly protected by a ridge of shingle similar to that opposite Lancing. The sea is, however, constantly sweeping this ridge backwards and encroaching on the land.

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(3) *About* 1 *Mile between Littlehampton and Bognor, Sussex.*

1. A small portion of the English coast midway between Littlehampton and Bognor, Sussex, for about one mile in length opposite the old Coastguard Station, in the parish of Middleton.

2. It varies from low clay cliffs from 8 to 10 feet above H.W.M. to land which is below the level of H.W., but protected by the accumulation of beach.

3. Generally east and west, but at the east end of the frontage it trends rather towards the north.

4. South-west.

5. South-west, but the south-east wind will assist in piling up shingle when the groynes are placed in a certain direction, in this case pointing south-east.

6. I believe the flood tide flows eastwards until about $1\frac{1}{2}$ hour before H.W. It then turns and flows westwards.

7. (1) **a.** 16 feet. **b.** $11\frac{1}{2}$ feet (Admiralty Tide Tables). (2) I should say about 400 yards, but am not quite certain.

8. The area covered by the tide near H.W.M. consists of shingle, under which is a yellowish loamy clay. The foreshore consists of sand overlying chalk marl.

9. a. In the general line of coast about 150 feet in breadth, but there is a bay or sudden bend in the coast line where it measures about 270 feet, there being a large accumulation of shingle in this bay. **b.** In the general line, roughly speaking, about half the breadth would be above H.W.S.T., and about half below that level on the windward side of the old groynes, but less than that proportion below H.W.S.T. on the leeward side owing to scour. **d.** The largest are chalk flints, and would measure about 6 to 8 inches. **e.** The surface of the shingle is formed in 'spring' and 'neap fulls.' I took several sections of the surface in September, 1888, and found that they varied in height according to the situation. Thus in the bay the 'spring full' is about 4 to 5 feet above H.W.S.T., and the 'neap full' about level with H.W.S.T. In the straight line of the coast the 'spring full' is about level with H.W.S.T., and the 'neap full' about 4 feet below it. These differences may be due to the higher level of the planking on the groynes in the bay.

10. The shingle was being swept away in places when I first went there in September last owing to the defective state of the groynes, but it is now accumulating since I built new and more substantial groynes. I cannot say the rate.

11. The diminution was due, as I have said, to the worn-out condition of the old groynes.

12. a. The old groynes for the most part are at rightangles to the shore-line. **b.** I measured eight of them, and their lengths average about 240 feet each. **c.** All sorts of distances apart, but they would average about 100 feet. **d.** The old groynes have existed for many years, but I cannot say how long. The shingle of the 'spring full,' on the windward side of the old groynes, was about level with the top of the planking of the old groynes, but on the leeward side it is in some places 4 and 5 feet, and in others 8 feet, below the top of the planking. **e.** Timber piles and planking. **f.** They arrest the travelling of the shingle on the windward side, but on the leeward side, as generally happens in all 'right angle' groynes, the sea scours out the shingle, and thus H.W.M. encroaches nearer the land. [N.B.—I have referred here to the old groynes, but the new groynes I have built this winter are placed in a different direction, viz., pointing south-east. They are of timber, but are more substantially built than the old ones. The effect of them, which I ascribe to the direction, has been very striking, since they have been finished in accumulating beach and sand, both on their windward and leeward sides, so much so that the lower ends of the old groynes have been already nearly buried under the sand. They are each about 250 feet long, and are placed there about 400 feet apart, so that there will be rather less than one half the original number to maintain.

13. No.

14. a. Where there are cliffs, which I have referred to, they are gradually being worn back at the rate of about 4 to 5 feet per annum; but where the land is below high water the beach arrested by the groynes protects it. The beach, however, has occasionally at those low points been driven back inland and covered small parts of the estate. **d.** I have no data of this kind. **e.** No; where there is beach the cliff is still being worn back.

15. a. There is shingle all along the frontage I refer to, and it would in the low places be dangerous to the land if it were swept away for any length. **b.** In places where shingle has been swept away and the shore left bare it has been entirely due to the defective state of the groynes. Where substantial new groynes are erected they do for a time arrest the travelling of the shingle and deprive the coast further westwards of so much as they absorb; but when the groynes fill up towards the top of their planking, although if properly built and placed they may still continue from time to time to collect more, the greater quantity passes on to the westwards, the remainder going to increase the 'fulls,' and so drive the H.W.M. seawards. The result of this action may be seen between Lancing and Shoreham, further westwards, where, according to my measurement, owing to the groynes the beach has gained some 40 to 50 yards in breadth, driving high water so much seawards during the last ten years.

16. No.

17. No.

18. I do not think there are any.

19. It should be observed that this part of the coast is not protected by any sea-wall. It is dependent for its protection on the accumulation of beach; and as the beach can only be secured by the groynes, their proper construction and maintenance are of course of vital importance to the landowner where the land lies below the level of high water.

Norfolk Coast.

Great Yarmouth. By Major A. G. CLAYTON, R.E., Norwich.

1. Great Yarmouth, Norfolk.

2. Flat sand.

3. North and south.

4. Variable.

5. a. North-west. **b.** West north-west. **c.** Shingle does not travel.

6. North and south.

7. (1) **a.** 4 feet. **b.** 3 feet. (2) About 50 yards.

8. Sand; but at certain periods, generally spring and autumn, banks of shingle are thrown up.

9. d. About the size of a walnut. **e.** The shingle is in detached banks only.

10. Apparently diminishing.

11. Yes.

12. There are no groynes.

13. a. Between high and low water. **b.** Ballast for fishing smacks and for roads chiefly. **d.** No.

14. No.

16. No.

17. Yes. **a.** Denes. **b.** 5 feet and 8 feet **d.** No. **e.** No.

Cromer. By W. JAMES K. FROST.

7. (1) **a.** 16 feet. **b.** 12 feet. (2) **a.** 200 yards. **b.** 100 yards.

12. a, b, c. Tracing annexed showing particulars. **d.** (*a*) 8 feet (above usual beach level), tapering seawards to 3 feet. (*b*) From 8 to 4 feet. (*c*) From top of groyne to 3 or 4 feet. **e.** Timber. **f.** Accumulation of beach and protection of sea-wall erected about forty years ago. Their influence in accumulating beach is felt as far westwards as Runton, from 1 to 2 miles distant.

13. a. Mainly between high- and low-water marks. **b.** As building materials. For roads and to potteries. **c.** (*a*) Yes, purchased of lords of manors. (*b*) Surveyors of Cromer and neighbouring parishes. (*c*) Soho Mills Co., Staffordshire; potteries, and others by agreement with lords of manors. **d.** Yes; particularly at West Runton, and between East and West Runton, where large quantities of rock stones have been removed.

Estuary of the Humber.

By C. Fox STRANGWAYS, Scarborough.

1. Part of the estuary of the Humber.
2. Low cliffs of warp and boulder clay. **a.** About 12 feet. **b.** A foot or two below H.W.M.
3. East and west, curving to the north-east.
8. Principally mud, a little shingle.
14. a. Quarter of a mile west of Ferriby Sluice and at Ferriby Hall. **b.** Warp clay. Slightly below H.W.M. **c.** 150 yards and 80 yards respectively since Ordnance map sheet 86 was made. **e.** What little shingle there is does not appear to cause any difference.
16. The mud banks of the Humber shift and vary their position, and some of them have been embanked since the publication of the Ordnance map, and are now inhabited.

Northumberland, Durham, Cumberland, and Westmorland.

By Lt.-Col. MELVILLE, C.R.E., Newcastle.

1. My sub-district comprises Northumberland, Durham, Cumberland, and Westmorland. I see Tynemouth in Northumberland most frequently.
2. Cliff, sinking to sandbanks further north. **a.** Principally sandstone. **b.** (*a*) About 100 feet. (*b*) About 60 feet. (*c*) About 20 feet.
3. North and south.
4. South-west and east, especially the latter in spring.
5. a. East.
6. Southward.
7. (*a*) $14\frac{3}{4}$ feet. (*b*) $11\frac{1}{4}$ feet. (*c*) Average about 100 yards.
8. Sand with rocks in places.
10. Neither.
12. No.
13. No.
14. No.
16. No.
17. No.

Pensarn, near Abergele, Denbighshire, to Point of Ayr, Flintshire.

By C. E. DE RANCE, Stoke-upon-Trent.

1. Pensarn, near Abergele, Denbighshire, to Point of Ayr, Flintshire.
2. Sand dunes. **a.** Sand between Rhyl and Prestatyn, the dunes being wasted at high tides by the sea. **b.** 25 feet; 14 feet; 5 feet.
3. E.N.E.
4. W.N.W.
5. a. N.W. **b.** N.W. **c.** W.N.W.
6. W.S.W. to E.N.E.
7. a. (1) 27 feet. **b.** 14 feet. (2) At Rhyl, 700 yards; at Rhyl, 600 yards. Equinoctial spring-tide at Rhyl, October 6, 1873, was 17 feet above O.D.; high water-mark of 16 feet; tide, 11·43 feet above O.D.; low water of the same, 10 feet below O.D.

8. Sand with a narrow belt of shingle.

9. a. 80 to 100 yards. **b.** Above neap tide, high water-mark. **c.** E.N.E. **d.** Between Abergele and the mouth of the Clwyd 5 to 7 inches; also in the shingle banks east of Prestatyn opposite Gronant, which project E.N.E. from the land towards the mouth of the Dee, the slope is steep and the banks above 12 feet in height. Between Rhyl and Prestatyn the pebbles are small, and chiefly derived from the Clwyd, which cuts off the eastward passage of the shingle.

11. At the mouth of the Clwyd it is diminishing, large quantities being daily removed by flats and taken to Liverpool for ballast. At Rhyl it also wasted away.

12. No.

13. Shingle is removed for building purposes by private individuals, with the consent of the local authority, who also take it for footpaths.

14. Between Abergele and Rhyl the coast is embanked by the London and North-Western Railway. **a.** Previously there was great denudation, and Abergele parish formerly is stated by tradition to have extended far out to sea, and this is supported to some extent by a tombstone, in the churchyard, with a Welsh inscription of the sixteenth century.

17. Sand dunes, rising to about 26 feet, extend from Pensarn, near Abergele, to the point of Ayr, except at Rhyl, where they have been removed artificially. **c.** Dunes occur on both banks of the River Clwyd; they rest in all cases on shingle. **e.** Stopped by growth of 'Starr' grass.

18. Mr. Fergie Hall, F.G.S., has described the probable wasting of Denbighshire, in historical times, in the 'Trans. Geol. Soc. of Liverpool,' 1869.

Hoylake to Birkenhead, Cheshire.

By C. E. De Rance, 55 Stoke Road, Stoke-upon-Trent.

1. Hoylake to Birkenhead, Cheshire.

2. a. Between Hoylake and New Brighton sand dunes rising to 30 feet above high water-mark; these rest on peat beds and grey estuarine, extending out to low water-mark, lying on boulder clay. **b.** At Leasowe an artificial embankment is constructed on peat beds below high water-mark.

3. E.N.E.

4. W. to N.

5. a. W. to N. **b.** N.W. **c.** W.S.W.

6. W.S.W.

7. (1) **a.** 27 feet. **b.** 14 feet. (2) 900 yards. The shore is known as Mockbeggar Wharf, the seaward margin of which is traversed by the Rock Channel, outside of which is the North Bank, a tract of sand several miles in extent.

8. The Hundred of Wirral in Cheshire is remarkable for its extent of coast-line. Rock occurs at Burton Point, Hilbre Point, New Brighton, and at Eastham. Shingle occurs from Nestor to West Kirby. Sand and peat from West Kirby to the Red Noses near New Brighton.

9. a. 50 to 100 feet in the estuary of the Dee. **b.** Immediately under the glacial drift cliff. **c.** S.S.E. on the east coast of the Dee. **d.** 3 to 4 inches. **e.** One slope under the cliff.

10. Constant now, but formerly diminished.

11. Being taken in 'flats' to Liverpool for ballast; this was stopped by the Crown agents, as it caused great erosion of the soft clay cliffs by exposing their base to the tidal current.

12. No; nor in the Dee, but between Hoylake and the Red Noses fascines are placed on the peaty shore, which wastes considerably except in the central portion, where it is protected by the Leasowe embankment.

14. a. Between Hoylake and New Brighton various old neaps show constant wearing back of the coast. The Leasowe Lighthouse having to be moved, the coast shows a much diminished outline to that found by the Ordnance Survey about forty years ago. **b.** No cliffs occur. **c.** The rate is over a yard a year. **e.** No shingle occurs.

16. None.

17. The dunes commence against a rock slope at West Kirby, and terminate against a similar slope at New Brighton. **b.** They rise to about 30 feet and rest upon peat, the surface of which is beneath high-water mark. **d.** They are prevented from increasing by the plantation of 'Starr' grass. In the centre of the area is a village called Great Meols, which name is believed to be of Danish origin, and to indicate that sand was there at that period. A very remarkable series of antiquities derived from this coast are preserved in the Liverpool Museum, ranging from Neolithic flint implements to coins of nearly all the English monarchs.

Liverpool to Lytham.

By Charles E. De Rance, Stoke-upon-Trent.

1. Liverpool to Lytham.

2. Between Liverpool and Southport a belt of sand dunes intervenes between the coast and the inner country, ranging in width from half a mile at Seaforth to 3 miles at Formby. **a.** Between Liverpool at the mouth of the Mersey, and Hesketh Bank at the mouth of the Ribble, no cliff occurs. **b.** Banks of boulder, 20 to 30 feet high, occur at Hesketh Bank and Freckleton Point on either side respectively of the trumpet-shaped opening of the estuary of the Ribble.

3. North and south. The Ribble estuary east and west.

4. West to north.

5. b. No shingle occurs over the whole of this coast-line, there being no material to furnish it except a little between Freckleton Point and Lytham.

6. From S.S.W. to N.N.E.

7. a. (1) 27·8 feet. **b.** 14·6 feet (Princes Dock, Liverpool). Highest spring above O.D. 12·65 feet; neap high mark above O.D. 7·25 feet; Ordnance datum 0·80 foot; true mean water-level below O.D. 0·68 foot; old dock sill, Liverpool, below O.D. 4·75 feet; Mersey tide gauge zero below O.D. 10·75 feet; lowest low water below O.D. 14·75 feet. (2) At Crosby 950 yards; at Ainsdale 1,800 yards. Outside the Channel very extensive sandbanks occur several square miles in extent.

8. Between Liverpool and Southport, sand; between Southport and Hesketh Bank of estuarian clays very finely laminated, especially on the coast margin. From Freckleton Point to Lytham Sand very large sand banks occur at the mouth of the estuary of the River Ribble.

9. Between Liverpool and Southport only a few scattered and far-between pebbles occur; these are probably seaweed-borne.

15. No.

16. Between Hesketh Bank and Crossness a very large area of marsh land was reclaimed by the late Mr. J. Fleetwood, of Bank Hall, for which he received the medal of the Society of Arts. **a.** At Southport the Corporation has reclaimed by embanking of tidal foreshore during the past twenty years, making building land within sea-walls, and a further large tract occupied in gardens, and a marine lake protected by embankments, the present high-water mark being half a mile from that of 1869. **b.** Southport is about 1,600 yards from the old coast-line, and is out of the water at equinoctial low tide.

17. A very extensive area between Waterloo, north of Liverpool, and Meols, north of Southport, being 3 miles across at Formby over the whole of the district. **c.** The sandhills stop at Meols, the supply of sand being cut off by the estuarine clays forming the foreshore. **d.** Stopped by planting. **e.** *Ammophila arundinacea,* or marram, is everywhere grown. In 1690 the deep-water channel left Formby, and sand began to blow, covering up the churchyard and streets; but, in North Meols, Jameson in 1636 describes the sandhills. It is probable they are of older date, as in William II.'s reign Roger de Poicton gave the monks of Lancaster the tithes of 'Melis,' and that name would indicate sandhills, as it is still used in Iceland for sandhills, there made up of volcanic sand.

Lytham to Fleetwood.

By C. E. De Rance, Stoke-upon-Trent.

1. Lytham to Fleetwood.

2. Between Lytham and Blackpool, sand dunes. Between Blackpool and Norbreck, glacial drift, clay and sands. Between Norbreck, Rossall and Fleetwood, sand dunes. **b.** Ranges from 25 feet to 90 feet at Bispham. Much of the areas north and south lying behind the sand dunes is beneath H.W.M.

3. North and south as far as Rossall Point. Between Rossall Point and the mouth of the Wyre, east and west.

4. West to north.

5. a. North-west. **b.** North-west. **c.** W.S.W.

6. E.S.E. at the mouth of the River Ribble; S.S.W. to N.N.E. to Rossall Point, thence to Wyre from W.N.W. to E.N.E.

7. (1) 28 feet; (2) 14 feet. At Blackpool (1) 800 yards; (2) 500 yards.

8. Fringing the cliffs of shingle, thence to ebb low water of sand, then of boulder clay, which also occur under the shingle; land water percolating the latter flows over the surface of the clay in defined channels 10 inches deep and 6 inches wide.

9. a. 150 feet; 300 feet in the Blackpool area. Near Lytham occurs a miniature chesil bank called the Double Stanner, which is steadily advancing; between it and the coast is a flat 600 ft. wide; at the open end water flows through it from the land. **b.** It terminates seawards a little above neap low-water mark. **c.** North. Encaustic tiles during the storm of March 1869 travelled from south shore to the Gwyn in two tides a distance of a mile. **d.** 7 inches; between neap low-water and spring low-water many erratic boulders occur, some 6 feet in length. **e.** There is generally a 'storm beach' of very large pebbles from 3 to 5 feet above the 'spring full.' At Norbreck each tide receding leaves a succession of small 'fulls.'

10. The quantity appears to be constant, except opposite South Beach, Blackpool. At Fleetwood the shingle is accumulating; it is cut off by the River Wyre.

11. Entirely due to artificial abstraction at South Beach, Blackpool.

12. a. Yes. That at Bailey's Hotel is at right angles to the centre of the curved sea-wall protecting that property; the wall and the groyne were built about 1880, and have stood very well. **b.** 8 feet. **c.** 2 feet. **e.** Wood battens and square piles. A groyne of sheet iron below Uncle Tom's Cabin was destroyed by the waves. Several wooden breakwaters are placed opposite South Beach, Blackpool, and Fleetwood; they cause an accumulation of shingle on the lee-side.

13. Shingle is indiscriminately carted away at Blackpool from any part of the shore by (c) at a greater distance than 60 yards from the coast line; the underlying boulder clay is exposed by these operations, and is extensively denuded by the sea, which gets leverage on its surface by the tearing up by the waves of the large erratic boulders scattered through its mass; the large blocks remain, but the smaller stones are swept up the beach, which is thus steadily replenished. The holes left vacant by the removal of stones are oval, the long axis corresponding to the tide, or N.W.E.

14. a. Yes, especially between Blackpool and Norbreck and Bispham. The cliffs are 80 to 90 feet high, and consist of boulder clay, with a thick sand intervening. Some years a loss of a yard takes place. And also between Bispham and Rossall, where the sea-wall built by Sir Hesketh Fleetwood has been allowed to be destroyed. **c.** Shingle occurs on the face of the cliff; the erosion is caused by (*a*) wind blowing away the sand and (*b*) land-springs, removing the base of the sand, where it rests on the lower boulder clay. **d.** There is a tradition that the cliff formerly extended to the large mass of consolidated sand and gravel called the 'Penny Stone,' and that a gallon of beer was at that period sold for a penny. There can be no doubt that it once formed the base of the cliff, as the material only occurs on the surface of the lower boulder clay. The Penny Stone is only seen at equinoctial springs.

15. After the heavy storm of March 1869, I found all the minor beach-fulls gone, and the whole of the beach concentrated into one large stone beach under the base of the cliff, and the sand in front of Blackpool also removed, showing an extension surface of boulder clay from the height of erratic boulders then exposed; I infer the sand removed was 4 feet thick; in a few tides the normal conditions were restored.

16. The steep bank of shingle between Lytham and Southshore is certainly increasing; sand blown from the shore rests on the stone beach, and forms fresh sandhills on the seaward side of the older one, causing a distinct gain of land; the large sandbank seaward, known as the 'Crusaders,' also is increasing.

17. Dunes extend from Lytham by St. Ann's to Southshore; they rest inland on peat, along shore on shingle. **a.** Sandhills. **b.** 20 to 40 feet. **e.** Kept down by bent grass, locally called 'Starr' grass. The site of the town of Fleetwood was formerly occupied by sandhills, one of which has been preserved to form a garden, and is known as the 'Mount.' Great destruction of the coast took place in 1869, houses being destroyed, but this has been stopped by sea wall and groynes.

18. Rossall 'land mark' formerly stood 100 yards further than at present, and was erected on a massive stone base, which when the sea reached it was removed inland of the house marked on the one-inch Ordnance Map as 'Fenny's.' There is no vestige of it left, though it had been twice removed before occupying the site shown in the Ordnance Map of 1848.

19. In the estuarine silt, near the site of the present Rossall landmark, a large number of Roman coins were discovered, marking the site of top, probably of an old Roman military chest; the level of the silt below the overlying blown sand resting on it is below the present H.W.M., pointing to the levels of land and sea, remaining constant since Roman times.

Erosion of Yorkshire Coast.

By Captain A. H. Kenney, R.E., February 1890.

The following notes on the above subject were forwarded to the Director-General of the Ordnance Survey, and communicated by him to the Committee:—

1. The sea is gradually encroaching on the whole line of coast from Bridlington to Spurn Head. The foreshore is all sand, the cliffs are all clay; there are no rocks whatever along this coast. The high tides with an in-blowing wind undermine the cliffs, the tops of which eventually slip or fall, and the continuous action of the sea washes such slips or falls away. At Bridlington, Hornsea, and Withernsea substantial sea-walls and groynes have been constructed to stop further encroachment.

2. The following measurements give in feet the actual encroachments since the 6-in. survey at definite points, from which the average encroachments on the coast line in the different 6-in. Yorkshire sheets mentioned have been deduced, viz.—

			Erosion
Point A.	Sheet 197	(Coast line surveyed but not examined yet)	165 ft.
„ B.	„	ditto	198 „
„ C.	„	ditto	198 „
„ D.	„	ditto	165 „
	Average erosion in Sheet 197 = 182 ft.		
Point A.	Sheet 213	(Coast line examined)	244 ft.
„ B.		ditto	251 „
„ C.		ditto	218 „
„ D.		ditto	244 „
„ E.		ditto	231 „
„ F.		ditto	231 „
	Average erosion in Sheet 213 = 237 ft.		
Point A.	Sheet 228		132 ft.
„ B.	ditto		165 „
„ C.	ditto		165 „
„ D.	ditto		99 „
„ E.	ditto		106 „
„ F.	ditto		158 „
„ G.	ditto		145 „
	Average erosion in Sheet 228 = 139 ft.		

		Erosion
Point A.	Sheet 243	158 ft.
„ B.	ditto	207 „
„ C.	ditto	383 „
„ D.	ditto	198 „
„ E.	ditto	218 „
„ F.	ditto	251 „
„ G.	ditto	264 „
„ H.	ditto	277 „

Average erosion for Sheet 243 = 245 ft.

Point A.	North half of Sheet 257	251 ft.
„ B.	ditto	251 „
„ C.	ditto	244 „
„ D.	ditto	277 „
„ E.	ditto	343 „

Average erosion in Sheet 257 N. = 273 ft.

Average erosion from Sheet 197 to 257 N. = 215 ft.

Average erosion per year = 5 ft. 10 in. nearly. The number of years being 1889–1852 = 37 years.

If the Director-General desires it, I could mark the points from which these measurements have been taken on the 6-in. sheets, lately forwarded with the present coast line inserted on them, if they are returned to me for this purpose, or I could forward 6-in. sheets which have been used in this office with these points marked on them. I regret I have no information as to heights of cliff beyond the levels and contours shown on the 6-in. sheets.

I attach a list of measurements to present top of cliff, and H.W.M. from certain ancient and permanent fixed points inland. A copy of this list was sent some time ago to the Secretary of the Coast Erosion Committee.

6-inch Sheet and Plan	Parish, &c.	Name of Fixed Object	Nearest Measurements in Feet		Measurements due East in Feet	
			To Top of Cliff	To H. W. Mark	To Top of Cliff	To H. W. Mark
197–3	Hornsea .	St. Nicholas' Church Fr. △	2,810·0	3,141·0	3,225·0	3,339·0
„	„	Do. chancel end .	2,695·0	3,026·0	3,095·0	3,229·0
213–9	Aldborough	St. Bartholomew's Church Fr. △	5,703·0	5,813·0	6,823·0	6,945·0
„	„	Do. chancel end .	5,604·0	5,714·0	6,717·0	6,839·0
„	„	Old Windmill (Cen.) (Corn.)	5,307·0	5,432·0	6,364·0	6,479·0
228–7	Hilston .	St. Margaret's Church Fr. △	3,215·0	3,308·0	3,940·0	4,047·0
„	„	Do. chancel end .	3,170·0	3,263·0	3,885·0	3,992·0
228–11	Tunstall .	All Saints' Church Fr. △	2,135·0	2,194·0	2,624·0	2,714·0
„	„	Do. chancel end .	2,075·0	2,135·0	2,548·0	2,640·0
243–5	Withernsea	St. Nicholas' Church Fr. △	920·0	1,213·0	1,282·0	1,478·0
„	„	Do. chancel end .	840·0	1,137·0	1,186·0	1,382·0
257–2	Holmpton .	St. Nicholas' Church Fr. △	3,203·0	3,317·0	4,093·0	4,195·0
„	„	Do. chancel end .	3,145·0	3,273·0	4,038·0	4,140·0

A copy of this list of present measurements from fixed points inland was sent to the Rev. E. M. Cole, Vicar of Westwang, Secretary of Yorkshire Coast Erosion Committee.

Report by Captain C. E. Salvesen, *R.E., July* 1892. *Communicated by the Director-General of the Ordnance Survey.*

In accordance with the Director-General's instructions, dated May 9, 1892, I now forward 6-inch sheets 163, 180, and 197, on which have been accurately drawn from the new $\frac{1}{2500}$ plans (surveyed in 1890) the 'top of cliff' R.W.M. O.T., L.W.M. O.T., extent of shingle, groynes, new beach marks and levels, and other details that I consider will be useful in the question of erosion.

All additions to the 6-inch sheets named, with the exception of L.W.M. O.T. (which is shown by a black line edged with blue), have been inserted in red.

The total length of the coast lines on 6-inch sheets 163, 180, and 197 is 12 miles 56 chains, and the total erosion from old top of cliff to new top of cliff is in this distance 204·026 acres, giving an average width to the strip of coast removed of 132·5 feet. Taking the total time as forty years (6-inch sheets surveyed 1850–52, $\frac{1}{2500}$ plans in 1890), the yearly rate of erosion comes to about 3 feet $3\frac{1}{2}$ inches. The actual areas for separate sheets are as follows, viz.—

Yorkshire 6-inch sheet 163 . . .	59·147 acres	giving average width of strip	
" 180 . . .	59·593 "		=118·86 feet.
" 197 . . .	85·286 "	do.	157 67 "
Total	204·026		

The last result—viz., 157·67 feet—disagrees slightly with that arrived at by Captain Kenney, R.E.; but his was only the average of four measurements, which would hardly give such an accurate result.

I have in each case calculated the area from old top of cliff to new top of cliff, as this represents the amount of land that is or probably could be put under cultivation.

The average height of the cliffs in 6-inch sheets 163, 180, and 197 is 39·34 feet.

This result has been arrived at by computing the area of an elevation of the coast-line made from data on the 6-inch sheets and new $\frac{1}{2500}$ sheets (B.M.'s pickets and contours) and dividing by the total length of coast—viz., 12 miles 56 chains. Multiplying the average width (132·5 feet) by average height (39·34 feet) and total length (12 miles 56 chains), the result is 12,955,666 cubic yards of material washed away in forty years, or an average of 25,503 cubic yards per mile per annum.

Report by Captain W Russell, *R.E., July* 1892.

I forward herewith (Yorkshire) 6-inch sheets 47, 62, 77, 78, 94, 110, 111, 128, 129, and 146, on which have been shown the present high and low-water mark of ordinary tides as obtained by the revision of the survey, and also any alterations in the line of the tops of the cliffs.

From these it will be seen that the only place where the erosion has been at all serious is at and south of Bridlington, and also just south of Filey.

All the rest of the coast being high cliffs, the action of the sea has been very slight, and indeed along the greater portion there is no appreciable difference between the old and new surveys. I also forward a report from T. C. A. Crook, who has been in charge of the revision of the whole of the coast from Bridlington to Whitby, in which he replies categorically to the questions asked.

The revision of the coast has as yet only been completed as far north as Whitby, and beyond that town I am not able to afford any reliable information.

The distances between the old and new lines of the top of the cliff at various places have been measured on the 6-inch plans, and are approximately given in feet for purposes of comparison in the attached list.

1.—That portion of the east coast lying between Bridlington Quay and Whitby.

2.—It is composed principally of rock and chalk cliffs interspersed with sandy bays, these latter being usually bounded by cliffs of alluvial soil. The whole of the line of cliff from Bridlington to the Humber consists of a varying cliff of brown unstratified clay and gravel from 20 to 50 feet high, the average probably about 25 feet. From Bridlington northwards to Speeton the cliffs are of chalk, forming the eastern boundary of the Yorkshire Wolds. These range in height from 50 feet at Bridlington to near 400 feet at Speeton; the average will probably be about 200 feet. Continuing northwards from Speeton to Filey, the cliffs are formed of boulder clay, and are of a pretty uniform height, averaging 100 feet. From Filey to

Scarborough the cliffs consist of Oxford clay, calcareous grit, sandstone, and limestone, the whole being surmounted by a considerable thickness of boulder clay. (In the two small bays lying between these points, called Gristhorpe and Cayton Bays, the cliffs are principally of boulder clay with here and there a little shale and sandstone). These cliffs are undulating and vary in several places from 100 to 200 feet; the average will probably be about 180 feet. The Scarborough Castle Rock consists of limestone and sandstone (Dogger Oolites), and rises 240 feet above high water. And from hence, for upwards of a mile north, the cliffs are of boulder clay, which again changes to rock; but for yet another mile it is principally boulder clay with here and there a small cliff of sandstone at the bottom, after which, continuing northwards to Hayburn Wyke and Peak, the cliffs rise, till at Peak they attain a height of 600 feet, and consist of shale, sandstone, and limestone, running from 100 feet at Cloughton (where thin veins of coal were formerly worked) to 600 at Peak, the average height probably being about 200 feet. From Peak to Robin Hood's Bay the cliff consists of the lower lias, shale, sandstone, and boulder clay, principally the latter. Here appear for the first time the large quarries of shale from which alum was formerly abstracted. The height ranges from 350 feet near Peak to 100 feet at the Bay, the average being about 140. From Robin Hood's Bay to Whitby the cliffs consist of the upper and lower lias, shales and their divisions, and sandstone. Old jet pits are numerous in these cliffs: they are of a pretty uniform height, averaging about 200 feet. From Whitby for about 2 miles N.W. the cliffs are of boulder clay, with here and there a little shale and sandstone, and average about 100 feet in height.

3.—The general line from Bridlington to within 1½ mile east of Whitby is north-west and south-east; from this point northwards it turns west by north.

4.—This depends upon the season of the year. In winter (which usually lasts six months of the year on this coast more or less) the prevailing wind is north-easterly and northerly; in summer it is south-east and by south, veering to south south-west in the late afternoon and evening.

5.—A north-easterly and north-westerly sea brings the highest waves; a northerly sea brings up the shingle, and the backsweep of the ebb with a north-easterly wind takes it away. This will be generally correct, but the fact is there is but very little shingle on this coast, and this only in the bays, and it would be better described as large gravel, and would be covered three-fourths of the year by a more or less thick layer of sand. A strong westerly wind off the land will cause a sea that will lift this sand, and leave bare the beds of shingle or gravel; but this again is not wholly accurate as applying to all the bays, for the bays at Whitby, Robin Hood's Bay, and Scarborough have eddies of their own; that in Scarborough South Bay being very strong, and due to the projecting coast line south of the town and Filey Brigg, and deposit left in Scarborough South Bay would be caused by the ebb, while in Whitby and Robin Hood's Bay it would be caused by the flood. In Filey and Bridlington Bays there are no eddies to speak of; the projecting Brigg at the north of Filey Bay and Flamborough Head on the south make this a comparatively still bay, while the large sandbank off Bridlington Quay, called, I think, the Smithies, and forming a long bar about 1½ mile from the shore, has the same effect here.

6.—North-west during flood and south-east during ebb, but the true current is not reached under a mile and a half or two miles from the shore, as the contours of the coast and the bays cause deflections from the true current.

What is the range of the tide?

(1) Vertical in feet.

Between 15 and 16 feet at spring and 11 at neap tides.

7.—This varies greatly. In Bridlington Bay I should think from 250 feet at neap to 500 feet at spring tides. Around Flamborough Head there are places where it never leaves the cliff face, but the average would be about 70 yards at neap to 110 at spring. In Filey Bay it would be about 300 feet at neap to 450 feet at spring. At Filey Brigg, which is a reef of flat rocks, it would be greatest about 700 feet at neap and 900 feet at spring. A little north of Filey Brigg the water scarcely leaves the foot of the cliffs, after which come beds of the flat rocks and shingle bays reaching to Scarborough; these at neap will average 300 feet and 400 feet at spring. In Scarborough South Bay it will be about 240 feet at neap to 340 feet at spring, around the castle rock 50 feet and 70 feet. In the North Bay the average will be 350 feet at neap and 450 feet at spring; thence on to Peak the average will be 90 feet and 120 feet; in Robin Hood's Bay 200 feet at neap and 300 feet at spring;

from Robin Hood's Bay to Whitby the average will be 120 feet to 200 feet; in the bay west of Whitby 200 feet at neap, 300 feet at spring.

8.—In the bay west of Whitby it is sand nearly the whole year through, but occasionally beds of shingle and gravel are visible; at Robin Hood's Bay it is sand and shingle mixed. After heavy seas most gravel will appear, but in the summer it is mostly sand; but this applies only from the bottom of the cliff for about 40 yards seawards; beyond this it is beds of flat rocks strewn in places with large boulders. The Scarborough North Bay is of the same character as Robin Hood's Bay, the South Bay is all sand, with a rim of shingle and boulders at the cliff foot 20 yards wide; at the south end of the bay Gristhorpe and Cayton Bays are mostly shingle for about 30 yards from the cliff foot, and flat rocks and boulder beds beyond. Filey Bay is all sand, stretching for about 3 miles; Bridlington Bay is all sand, excepting about 3 miles of the north side forming the Flamborough Head projection, which is flat rocks and boulders. Excluding these bays, all the remaining and by far the greater portion of this coast consists of beds of large boulders (ranging from a few hundredweights to several hundreds of tons) and beds of flat rock mostly strewn with boulders, but bare in those parts where from their position the seas break over them with violence.

9.—As already stated, there is scarcely any shingle worth calling so on this coast; where there is, its greatest breadth would not exceed 40 yards, while the mean would be between 20 and 30, and this would be in all cases at the cliff foot. The high-water mark of an ordinary spring tide would about equally divide it, *i.e.*, half would be covered and half dry. In all cases it would travel south, barring the influence which the eddy and a south-east wind may have in moving it a little north; but this rarely occurs, and is so trifling in its effect as not to be worth mentioning. It is sufficient to say that no wind that blows can take anything north betwixt the Tyne and Flamborough Head. This is proved by the fact that portions of vessels wrecked about the Tyne's mouth are picked up all down the coast to Flamborough Head, but no portion of the wreckage of any vessel wrecked, say, at Flamborough Head, Scarborough, or Whitby, has ever been found north of those points. The egg of a goose would represent the size of the largest pebbles, and these occur at Cayton Bay. The shingle forms one continuous slope; there is no 'spring full' or 'neap full.'

10.—The shingle is certainly not accumulating, and on the other hand the diminution is too small to be perceptible, and the rate cannot be ascertained. From Bridlington to Whitby the foreshore, wherever accessible, is the great quarrying ground for the wants of the immediate neighbourhood, sand, shingle, and boulders alike being obtained as required, and this must certainly diminish the amount; but this is probably made up again by the frequent falls of cliff which occur after heavy seas and through springs in the cliff.

12.—There are no groynes on this line of coast, with the exception of two or three at Bridlington Quay, built for the protection of the sea-wall or promenade there. These are built at right angles to the shore line; their length and distance apart can be obtained from the plans, their height ranges from about 7 feet at the shore end to 2 feet at the other. I have no knowledge of where they were built, and there is no shingle at this place—they are built of masonry and wood.

13.—The material is taken indiscriminately from all the foreshore between high- and low-water mark. The shingle and boulders are mostly taken for road and path making, the sand for building and other purposes, and large boulders are taken for building purposes. It is mostly taken by highway and local board authorities, and by lords of the manor, who levy a toll upon all private individuals taking it with their consent. No half-tide reefs are known to have existed before such removal, but it is certain that these large boulders (and at Scarborough even the reefs of flat rocks are being quarried), shingle, and sand form a breakwater, which breaks the violence of the waves, and consequently their removal cannot but affect the cliffs in their neighbourhood.

14.—The coast is being worn back along the whole line from Bridlington to Whitby, but the greatest recession is between Bridlington and the Humber, where in places it has receded as much as 90 yards between the present survey and that made forty-three years ago, and it has been computed that 2 yards go annually along this line of coast. In all the bays, Filey, Robin Hood's, Whitby, and the smaller ones (Scarborough is in part protected by a sea-wall), where the cliffs are mostly of boulder clay, there the recession has been most. The average width lost in these during the above period would probably be about 20 yards, in places much more, in others less. After the boulder clay the shale and sandstone cliffs, as between Peak and Whitby, appear to be least able to withstand the onslaught—the rate of recession here, taking the same period, would average 8 or 9 yards—more or less. The height of the clay cliff would be about 100 feet, with an average width from top to bottom of 60 yards. The height of the shale cliff would be from 150 to 200 feet, with an average width from top to bottom of 30 yards, although they are in many cases nearly perpendicular. The chalk cliffs of Flamborough appear to stand the influence of the sea best; the average recession there, I should say, would not be more than 2 or 3 yards during the same period. When there are large beds of boulders at the foot of the cliff, and the cliffs themselves are destitute of springs, there is scarcely any difference between the line as now surveyed at foot of cliff and that surveyed forty years ago. I know of no data for determining the rate except the 6-inch Ordnance Survey made about forty years ago.

15.—The loss is not confined to areas bare of shingle; the amount taken is retrieved by the amount made by falls of cliff. There are no groynes for the arresting of shingle.

16.—There is no area regained on this line of coast.

17.—There are no dunes in this district. I have heard they exist at Redcar, but have no personal knowledge of them.

18.—I have been unable to obtain any information in this respect. I recollect reading at Bridlington, in a local history or newspaper, the effect of the sea on that line of coast, and I think it probable some information might be obtained there.

19.—I have no remarks bearing on the subject that are not covered by the foregoing replies.

To Captain W. Russell, R.E.

Ordnance Survey, Whitby, June 13, 1892.

Sir,—I beg to state that the attached report is made from my own memory and knowledge, and from what I have heard. I have been unable to obtain any information from any book, newspaper, or report beyond a geological map which I saw in Scarborough Museum when there during the week, so that I cannot verify my statements, but I believe they are as nearly accurate as it is possible to get in a statement of this sort.

(Signed) S. Crook.

List of Differences between 6-inch Scale Maps and $\frac{1}{2500}$ Scale Revised Plans, showing how far the Bank or Cliff has broken away since the 6-inch Scale Survey, at the points indicated, measured from the 6-inch Map.

6-inch Sheets	Reference Letter	Distance in Feet
		Approximately
146	A	82
146	B	198
146	C	264
146	D	50
128	E	16
129	F	18
111	G	66
110	H	66
110	K	92
94	L	33
94	M	82
94	N	66
78	O	56
77	P	92
47	Q	100

Erosion of Coast of Lancashire since 6-inch Survey, July 23, 1892.

Report by Captain A. D. Meeres, *R.E.*

I have to report that the greatest encroachment of the sea on the Lancashire coast between the Duddon and Ribble estuaries has taken place:

1. On the S.W. coast of Walney Island, where in one place ($\frac{1}{2500}$, plan $\frac{27}{7}$) the coast line has receded nearly half way across a narrow part of the island.

2. At Rossall Point, where about 420 feet has been washed away since the 1844–45 Survey.

The coast at both of these places is, generally speaking, low, with sand and shingle foreshore and no rocks.

The amount of erosion varies so much that I have been unable to arrive at a satisfactory average for each 6-inch sheet, but in attached list are given the maximum amounts of erosion at each place, and on accompanying 6-inch sheets (21, 27, 28, 22, 38, 37, 42, 58, 59, and 67) the present coast line is shown in red, where it differs materially from the old, with some measurements of the extent of encroachment at those points marked. The measurements in all cases are taken from $\frac{1}{2500}$ traces, except for Sheets 58 and 67, where the coast line was not replotted.

I may add that the gain of land along this coast is, owing to the extensive reclamation in the Ribble estuary and the construction of the Furness Railway, probably far greater than the loss occasioned by erosion. There is also a slight gain at places near Barrow, due to slag from ironworks being tipped in the sea, forming embankments.

(To accompany Capt. Meeres's Report of July 23, 1892.)

6 inch Sheet	Remarks	Maximum Erosion in Feet
10	No appreciable change	
15	Slight changes in coast line of sandhills, but not of importance	
21	Slight erosion from Earnse Point to about 30 chains south,	59
	and for a length of 30 chains at Tummershill, Rabbit Warren	86
27	Considerable encroachment of sea. Maximum about 600 yards north of Trough Head. Groynes now erected where shown on 6-inch map	720
28	Some erosion on the S.E. end of Walney Island, on the South Coast	158
	At east extremity the coast lines are not well defined, but there appears to have been erosion going on at N.E. point, now a groyne near S.E. point . . .	260
22	Some erosion from Rampside to Point of Comfort, and	165
	slight amount from ¼ to ½ mile south of Aldingham Church	66
16, 17, 18, 24, 30, 29, 33, 34, 39	No erosion of importance	
38	About 2½ miles east of Fleetwood erosion for a length of 28 chains,	132
	and some more to the west of Fleetwood, commencing at the west end of the town and extending nearly to Rossall Point	196
37	A considerable encroachment of the sea at Rossall Point, gradually diminishing to the south	422
42	Continuation of above to about ¾ mile south of Rossall School, except for a length of about 400 yards, opposite Rossall School, where there is a substantial sea-wall and no change in coast line	
	There are now groynes along this portion of the coast .	263
50	No change of importance	
58, 59, 67	A considerable encroachment extending from about 1½ mile N.W. to about 1 mile S.E. of St. Anne's . . .	390

APPENDIX IV.

SECOND CHRONOLOGICAL LIST OF WORKS ON THE COAST-CHANGES AND SHORE-DEPOSITS OF ENGLAND AND WALES.

By W. WHITAKER, B.A., F.R.S., F.G.S., Assoc.Inst.C.E.

This being the final Report of the Committee, it is well that the bibliography in an earlier Report should be supplemented and continued. The 431 entries therein carried the list to the middle of 1886, and now 18 are added, from 1815 to 1885, 6 for 1886, and 52 from 1887 on, or 76 in all, bringing the total to 507, to which probably many additions can be made from local sources.

1815.

Kidd, Professor J. A Geological Essay. . . . chap. xxii. On the Action of the Sea upon the Land. (Ramsey, near St. David's, pp. 215, 216.) 8vo. *Oxford.*

1840.

Clarke, Rev. W. B. On the Geological Structure and Phænomena of the County of Suffolk. . . . Causes in Action. (Coast, Bawdsey to Walton Naze) pp. 366, 367. *Trans. Geol. Soc.*, ser. 2, vol. v. p. 359.

1854.

Oldham, James. On the Physical Features of the Humber. *Rep. Brit. Assoc.*, 1853, pp. 36–45, pl. 2.

1856.

Redman, J. B. Report on Sandown Castle. Together with a Letter from the Secretary of State for War to the Mayor of Deal. 8vo. *Lond.* [Printed at the War Office.]

1861.

Morton, G. H. On the Pleistocene Deposits of the District around Liverpool. (Refers to Submarine Forest.) *Proc. Liverpool Geol. Soc.* sess. 1, 2, p. 12.

1870.

Morton, G. H. Anniversary Address. (Refers largely to Submarine Forests.) *Proc. Liverpool Geol. Soc.* sess. 11, p. 3.

1872.

Ricketts, Dr. C. Anniversary Address. [Refers to Coast Deposits, &c.] *Proc. Liverpool Geol. Soc.* sess. 13, p. 3.

1874.

Reade, T. M. Tidal Action as a Geological Cause. *Proc. Liverpool Geol. Soc.* sess. 15, p. 50.

1875.

Kinahan, G. H. Valleys and their Relation to Fissures, Fractures, and Faults. (Refers to S. Devon Coast, pp. 36, 37, 81; to Romney Marsh, pp. 206–208.) 8vo. *Lond.*

1876.

Sawyer, F. E. The Erosion of the Sussex Coast, with special reference to Great Storms which have visited the County. 23rd *Ann. Rep. Brighton Nat. Hist. Soc.* pp. 129–138 (imperfectly entered in earlier list).

Tylor, A. Denuding Agencies and Geological Deposition under the Flow of Ice and Water . . . and similar remarks on Marine Deposits, illustrated by the Irish Sea and the Chesil Beach. *Geol. Mag.* dec. ii. vol. iii. p. 90. Fuller abstract than in *Quart. Journ. Geol. Soc.* vol. xxxii. *Proc.* p. 4.

1879.

Edwards, G. The River Waveney: did it ever reach the Sea *viâ* Lowestoft? 8vo. *Lowestoft*, pp. 20.

1880.

McDiarmid, W. R. Additional Note on the North-East Coast of Norfolk. *Trans. Edin. Geol. Soc.* vol. iii. pt. 3, pp. 292, 293.

1882.

McDiarmid, W. R. Second Additional Note on the North-East Coast of Norfolk. *Trans. Edin. Geol. Soc.* vol. iv. pt. ii. pp. 171–173.

1883.

Grantham, R. F. Land reclaimed from the Sea (with Discussion). *Trans. Inst. Surv.* vol. xv. pp. 297–324.

1884.

Shone, W. The Silting up of the Dee. *Proc. Chester Soc. Nat. Sci.* no. 3, p. 52.

Spratt [Rear-Admiral], T. A. B. Report on the Present State of the Navigation of the River Mersey. 8vo. *Lond.*

1885.

Blake, J. H. Geological Survey of England & Wales. Explanation of Horizontal Sections, Sheet 128. [Kessingland, Pakefield, Corton. Refers to waste of coast, &c.] Dated 1884 on p. 1, but 1885 on p. 8. 8vo. *Lond.* pp. 8.

1886.

Dowson, A. Groynes on Shifting Beaches (Brighton). *Engineer*, vol. lxii. pp. 346, 347.

Price, F. G. H. The Landslip in the Warren near Folkestone. *Geol. Mag.* dec. iii. vol. iii. p. 240.

Reade, T. M. Notes on a Bed of Fresh-water Shells and a Chipped Flint lately found at the Alt Mouth. *Proc. Liverpool Geol. Soc.* vol. v. pt. ii. pp. 137–139.

Redman, J. B. Tidal Approaches and Deep-water Entrances. *Trans. Soc. Eng.* pp. 143–168, pl. i.

Vernon-Harcourt, L. F. The River Seine. (Discussion. Refers to the Ribble, Humber, Mersey, Thames, and Tees, pp. 259, 260, 263, 264, 270–272, 285, 286, 291–296, 301–304, 308–312, 323, 324, 340, 341.) *Proc. Inst. C. E.* vol. lxxxiv. p. 210.

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1887.

Alcock, Dr. T. Natural History of the Coast of Lancashire. (Notices the shore and waste of coast at Blackpool, Southport, &c., pp. 4, 5, 8–10, 16, 21.) 8vo. *Manchester.* Pp. 31.

Black, W. G. Brighton Beaches after Storms of October 15 and December 8, 1886. *Trans. Edin. Geol. Soc.* vol. v. pt. 3, p. 399.

Dickson, E. Notes on the Excavations for the Preston Docks. *Proc Liverpool Geol. Soc.* vol. v. pt. iii. pp. 249–256.

George, I. E. Notes on some weathered Rocks at Hilbre. *Trans. Liverpool Geol. Assoc.* vol. vii. pp. 92–94.

Hunt, A. R. The Action of Waves on Sea Beaches and Sea Bottoms. [Lecture to Torquay Nat. Hist. Soc. 1883.] *Torquay Directory,* November.

Jukes-Browne, A. J. Memoirs of the Geological Survey. England and Wales. The Geology of East Lincolnshire. . . . (Submerged Forest, Blown Sand, pp. 109–112.) 8vo. *Lond.*

Miles, C. E. The Mersey Estuary. *Trans. Liverpool Geol. Assoc.* vol. vii. pp. 85–89.

Norman, M. W. A Popular Guide to the Geology of the Isle of Wight. . . . 8vo. *Ventnor.* The Red Beach, pp. 173–176. Landslips and loss of land, pp. 181–194.

Penney, W. Denudation of the Coast at Handfast Point, called in Captain Sherringham's Chart of Poole Harbour, Standfast Point. (Dorset Field Club.) *Poole and Bournemouth Herald,* September 15.

Potter, C. On the Sand-dunes of the Cheshire Coast. *Trans. Liverpool Geol. Assoc.* vol. vii. pp. 28–33.

Whitaker, W. Memoirs of the Geological Survey. England and Wales. The Geology of Southwold, and of the Suffolk Coast from Dunwich to Covehithe. (Coast Deposits, Waste of the Coast, pp. 45–51.) 8vo. *Lond.*

1888.

Curtis, R. H. The Cornish Blown Sands. *Nature,* vol. xxxviii. no. 968, p. 55.

Dickson, E. Geological Notes on the Preston Dock Works and Ribble Development Scheme. *Proc. Liverpool Geol. Soc.* vol. v. pt. iv. pp. 369–376, 2 plates.

Hunt, A. R. The Raised Beach on the Thatcher Rock : its Shells and their Teaching. *Trans. Devon. Assoc.* vol. xx. pp. 225–253.

Morton, G. H. [President's Address.] Local Historical, Post-Glacial and Pre-Glacial Geology. *Proc. Liverpool Geol. Soc.* vol. v. pt. iv. p. 303. [See pp. 307, 315–324.]

—— Stanlow, Ince, and Frodsham Marshes. *Ibid.* pp. 349–351.

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1889.

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Groves, T. B. The Erosion of the Coast near Weymouth by the Action of the Sea. *Proc. Dorset Field Club*, vol. x. pp. 180–186.

Morton, G. H. Further Notes on the Stanlow, Ince, and Frodsham Marshes. *Proc. Liverpool Geol. Soc.* vol. vi. pt. i. pp. 50–55.

Picton, Sir J. A. Notes on the Local Historical Changes in the Surface of the Land in and about Liverpool. *Ibid.* pp. 31–42.

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Cole, E. M. The erosion of the Yorkshire Coast. *Naturalist*, pp. 103–107.

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Stock, T. Somersetshire Sand-Tots : Their Geological History. *Ibid.* no. 328, pp. 75–77.

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Hutchinson, P. O. Landslip at Sidmouth. *Trans. Devon. Assoc.* vol. xxv. pp. 174, 175.

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Shone, W. The Submerged Forest at Rhyl. *Chester Chronicle*, Feb. 18.

Topley, W. The Landslip at Sandgate. *Proc. Geol. Assoc.* vol. xiii. pt. 2, pp. 40–47.

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Bird, C. On so-called Changes of Level [chiefly Kent]. *Rochester Naturalist* (Oct., 7 pages).

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Mc. Dakin, Capt. S. G. Coast Erosion. *S. E. Naturalist*, vol. i. pt. iv. p. 107.

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1895.

Hill, Rev. E. The Tower of Eccles-by-the-Sea. *Geol. Mag.* dec. iv. vol. ii. pp. 229, 230 (also various notices in local newspapers).

Hunt, A. R. A Note on the Torbay Raised Beaches. . . . *Ibid.* pp. 405–408.

Structure of a Coral Reef.—Interim Report of the Committee, consisting of Professor T. G. BONNEY (*Chairman*), Professor W. J. SOLLAS (*Secretary*), Sir ARCHIBALD GEIKIE, Professors A. H. GREEN, J. W. JUDD, C. LAPWORTH, A. C. HADDON, BOYD DAWKINS, G. H. DARWIN, S. J. HICKSON, *and* A. STEWART, Admiral W. J. L. WHARTON, Drs. H. HICKS, J. MURRAY, W. T. BLANFORD, LE NEVE FOSTER, *and* H. B. GUPPY, Messrs. F. DARWIN, H. O. FORBES, G. C. BOURNE, A. R. BINNIE, J. W. GREGORY, *and* J. C. HAWKSHAW, *and* Hon. P. FAWCETT, *appointed to consider a project for investigating the Structure of a Coral Reef by Boring and Sounding.*

THE Committee made an application to the Royal Society for an allocation of £500 from the fund granted by the Government in aid of Scientific Research. The Royal Society, as a preliminary to the discussion of the application, have written to the Admiralty to inquire whether the Government would be able to assist an expedition by putting a surveying vessel at its disposal. A reply from the Admiralty has not yet been received. The Committee ask to be reappointed with a renewal of the grant of £10, which had not been drawn.

The Circulation of Underground Waters.—Twenty-first Report of the Committee, consisting of Dr. E. HULL (*Chairman*), Sir DOUGLAS GALTON, Messrs. J. GLAISHER, PERCY KENDALL, Professor G. A. LEBOUR, Messrs. E. B. MARTEN, G. H. MORTON, Professor PRESTWICH, Messrs. I. ROBERTS, THOS. S. STOOKES, G. J. SYMONS, C. TYLDEN-WRIGHT, C. WETHERED, W. WHITAKER, *and* C. E. DE RANCE (*Secretary*). (*Drawn up by* C. E. DE RANCE.)

YOUR reporter has not received any reports from the Corresponding Societies since last year's meeting, but he has good reason to believe that valuable results have been collected, and locally published. These will be doubtless of great local value, and it is a source of satisfaction to see that the work originated by the Committee is likely to be permanently carried on by the local societies on the lines initiated by the British Association. Your reporter, however, would again point out that the collection of sections and details of water supply, by some central body, would be of great value to engineers, contractors, and others, who have neither time nor opportunity to seek the records of the various provincial proceedings, and it appears desirable that it be a suggestion to the Corresponding Societies that they annually send up the details they have obtained to the offices of the Geological Survey of the United Kingdom, 28 Jermyn Street, London, where a section-book is now kept, and every facility daily given to those seeking information.

Your reporter has not received any information from any member of the Committee during the past year, and therefore thinks it unadvisable to do more than present this formal report, without appendices of information personally collected by himself, as has been done on several previous occasions.

This being the final Report, it may be, in conclusion, advisable to state that the Committee have had the same chairman and secretary during the whole of their twenty-two years' labours, and they have arrived at the following general results, some of which are self-evident, but it is necessary to state, through simple conditions, not always universally understood.

1. The source of all water supply, whether in streams, wells, or natural springs, is the rainfall falling on the area, or that adjacent to it.

2. The quantity of water to be obtained under all three heads is that annually falling, less the quantity evaporated, and less natural loss through retention after natural filtration.

3. The quantity of underground water to be obtained in sandstones and grits is governed by the cubic content of the interspaces between the grains; the larger the spaces, the greater facility for the storage and passage of water, coarse grits amounting to 12 inches of the annual rainfall.

4. In calcareous rocks, as Carboniferous and Magnesian Limestones, oolitic calcareous rocks, and Chalk, the grains are exceedingly small, the spaces almost microscopic, and the passage of water through the rock exceedingly slow, but waters so passed are naturally and effectually filtered. But in rocks of this class open spaces, following lines of joint, faults, and other planes of weakness, constitute fissures and caverns, through which water flows freely in defined channels, as on the surface,

and, like it, is not subject to natural filtration, and, unlike it, has not the advantage of the purifying effect of sunlight on its passage.

5. When porous rocks of different characters are separated by thin beds of impermeable material, it is often possible to obtain several classes of water from one well, suitable or unsuitable, as the case may be, for the brewing of ale or stout, the dilution of spirits, or the exigencies of the wool or the indigo dyeing trades.

6. Where wells are pumped at the same daily rate without abstracting what the late Mr. Hawksley called 'water of cistonage,' the hardness is reduced after a year's pumping, and this remains stationary over proved periods of forty years. If the pumps are lowered, and the apex of the 'inverted cone' be placed still deeper beneath the mean sea-level, the width of the base of the cone is extended, and a new concentric circle of supply is added to the contribution ground; the water then hardens for a time, but after the soluble salts have been pumped out the degree of hardness remains constant as before.

7. Faults in porous rocks of whatever thickness, which were originally overlaid by porous rocks, no matter how great their throw may be, are no obstacles to the passage of underground water.

8. Where the same are, or have been before subsequent denudation, overlaid by impermeable material, the fissure of the fault is filled with impermeable material, and it forms a natural puddle trench separating the district into distinct watertight zones.

9. Where faults of the latter class exist, and the area on one side of the fault joins the sea, and a quantity of water is annually abstracted, exceeding the quantity absorbed by rainfall, the excess is derived from the sea, a reversal of the underground current taking place; and as this goes on the rock becomes surcharged with salts, and can no longer act as a filtering medium, and the water pumped daily approximates more and more to the sea water from which it is derived.

10. Engineers and architects, in many cases, do not realise the danger of placing public pumping stations where the area of supply includes sewage farms and objectionable trade refuse. It is exceedingly desirable that the officials of the Local Government Board should have their attention strongly drawn to this important matter.

11. This report is adopted by the Committee: they approve of the suggestion of the reporter, that the digest of the previous reports he has prepared be offered to the Geological Survey of England and Wales for publication, and they recommend that, should this offer be declined by the Survey, the digest be dealt with by its author as he may find expedient, and they recommend that in either case all blocks and plates used in the previous reports be placed at the recorder's disposal for the purpose of reprint.

APPENDIX.

SECOND CHRONOLOGICAL LIST OF WORKS REFERRING TO UNDERGROUND WATER, ENGLAND AND WALES.

By W. Whitaker, B.A., F.R.S., F.G.S., Assoc.Inst.C.E.

Since the publication of the list in the Thirteenth Report of the Committee, which ended with the year 1887, 37 additional titles for the years 1819 to 1887 have come to hand, of which 2 are different versions of previous entries. Besides these, 104 titles of works published from 1888 to 1895 carry on the list up to the time of this final Report. A few titles have been kept back, the papers not having been seen to.

The writer will be glad to know of any omissions in the lists, in view of the possibility of the whole being reprinted. He hopes, too, to keep the work up to date. The number of entries is now 695.

A bibliography of Mineral Waters having been made by **Mr. W. H. Dalton**, the reader is referred thereto: there is no need to enter here titles of works therein given. See *Rep. Brit. Assoc.* for 1888, pp. 859–897 (1889). This list has been reprinted with a few additions.

1819.

Lunn, F. On the Strata of the Northern Division of Cambridgeshire. (Wells and water, p. 116.) *Trans. Geol. Soc.* vol. v. pt. i. p. 114.

1870.

Moore, C. The Mammalia and other Remains from Drift Deposits in the Bath Basin. [2 well-sections at Bath.] *Proc. Bath Nat. Hist. Field Club.*

1872.

Hughes, Professor T. McK. Memoirs of the Geological Survey of England and Wales. Explanation of Quarter Sheet 98, S.E.; illustrating the Geology of the Neighbourhood of Kirkby Lonsdale and Kendal. 8vo. *Lond.* (Springs, Swallow-holes, &c., pp. 19–21.)

1874.

Keeling, G. Section in sinking for a Well near Lydney Basin. (Plate, in paper by W. C. Lucy.) *Proc. Cotteswold Nat. Club*, vol. vi.

1875.

Heriot, Captain M. The Bath Waters. *Proc. Bath Field Club*, vol. iii. no. 2, pp. 163–170.

—— The Mineral Spring at Batheaston. *Ibid.* pp. 171–177.

Topley, W. Report on the Water Supply of Hastings. Pp. 18. Fol. *Hastings.*

1876.

Boult, Joseph. An Inquiry into the Source of Water in the New Red Sandstone. Part 1. *Journ. Liverpool Polytech. Soc.* (April and May.)

1877.

Boult, Joseph. An Inquiry into the Source of Water in the New Red Sandstone. Part 2. *Journ. Liverpool Polytech. Soc.* (Feb.) pp. 18–47.

1878.

Lucas, J. Hydrogeology in its Relation to Water Supply. *Trans. Social Sci. Congr.* 1878, pp. 518–520.

1880.

Andrew, T. Observations on the Geology of Exeter, and the Improbability of there being a Subterranean Water Supply for Economic Purposes. *Trans. Sanitary Inst.* vol. ii. pp. 232–240.

Kinsey, W. B. Particulars of an Artesian Well at Thames Haven, Essex. [=Anonymous Paper of 1879 in List.] *Ibid.* vol. i. pp. 203–208.

Lucas, J. On the Quantitative Elements in Hydrogeology. [? = fuller version of Brit. Assoc. paper, 1879.] *Ibid.* pp. 195–202.

Perkins, F. P. On the Sanitary Condition of Wells in Exeter and Neighbourhood. *Trans. Sanitary Inst.*, vol. ii. pp. 240–245.

Stanley, W. F. Conditions of the Water Supply of Croydon, in relation to its Rainfall and Geology. . . . *Ibid.* vol. i. pp. 223–233.

Swete, Dr. H. Interpretation of Water Analyses for Drinking Purposes. (Refers to wells, &c.) *Ibid.* pp. 70–75.

1881.

Gilford, W. The Geology of this district, especially in reference to the question of Water Supply. *Proc. Holmesdale Nat. Hist. Club.* for 1879 and 1880, pp. 17–19.

Lucas, J. Rural Water Supply; with especial reference to the objects of the Public Health Water Act, 1878 (with Discussion). *Trans. Inst. Surv.* vol. xiii. pts. v. vi. pp. 143–200.

—— Wells, Springs, and Rivers of Great Britain. Return of Gaugings and other observations on . . . Subterranean Water Economy, by various observers. Nos. 1, 2, 3. 8vo. *Lond.*

Timins, Rev. J. H. On the Pollution of Wells in the Lower Greensand [Kent]. *Sanitary Record*, May 15.

1882.

Mansergh, J. Lectures. Water Supply. . . Well-sinking and Boring . . . School of Military Engineering, Chatham. (Underground Sources of Supply, pp. 81, &c., and plates of Well-sections.) 8vo. *Chatham.*

1884.

Easton, E. Hastings Corporation Waterworks. Report. Pp. 22. Fol. (? *Hastings*).

Spencer, J. P. Alnwick and Canongate Local Board of Health. Proposed additional Water Supply. Report. Pp. 7. 8vo. *Alnwick.*

Topley, W. Report on the Battle Water Supply (1883). Pp. 3. Fol. *Battle.*

1885.

Lucas, J. Alnwick and Canongate Local Board of Health. Report . . . on the Prospects of Boring for Water in Rugley Wood and at Thorntree Well. Pp. 7. 8vo. *Alnwick.*

Sutton, F. On a Highly Ferruginous Water from a Well at Kirby Bedon. *Trans. Norfolk Nat. Soc.* vol. iv. pp. 44–50.

Report of the Committee . . . on Decrease of Water Supply. *Quart. Journ. R. Met. Soc.* vol. xi. pp. 216–221, pl. 5.

1886.

Eassie, W. On the Waters derived from the Bagshot Beds, considered as Drinking Supplies. *Sanitary Record*, June 15 ; and *Trans Soc. Med. Officers Health.*

French, H. H. On 'Bournes.' *Trans. Leeds Geol. Assoc.*, pt. ii. pp. 51–53.

Lucas, J. On some recent Borings for Water [Cirencester, Bath, Spotsham (Surrey)]. *Prof. Notes, Surveyors' Inst.* vol. i. pt. i. pp. 14–18.

1887.

Bird, C. Underground Water. *Journ. Rochester Farmers' Club*, January. Pp. 13.

Hopkinson, John. Hydrogeology, in 'A Sketch of the Geology and Climate of Hertfordshire,' in Pryor's 'Flora of Hertfordshire.' *Hertford.*

Jukes-Browne, A. J. Water Supply, pp. 135–137. Well Sections and Borings, pp. 148–176, of 'Memoirs of the Geological Survey. England and Wales. The Geology of Part of East Lincolnshire. . .' 8vo. *Lond.*

Latham, B. Address (to Section ii.). (Refers to Underground Water.) *Trans. San. Inst.* vol. viii. pp. 163–165.

Pitt-Rivers, Lieut.-Gen. Excavations in Cranborne Chase. . . Vol. i. pl. v. and pp. 27, 28. Positions of Wells with the Depths. . . 4to. *Printed privately.*

Warington, R. A Contribution to the Study of Well Waters. [The Well Waters of Harpenden, pp. 520–552.] *Journ. Chem. Soc.* vol. li. p. 500.

Whitaker, W. Memoirs of the Geological Survey. England and Wales. The Geology of Southwold . . . (Well-sections, pp. 78–80.) 8vo. *Lond.*

1888.

Andrew, T. Some Notes on the Well at the Exeter City Asylum. *Trans. Devon. Assoc.* vol. xx. pp. 123–128.

Blake, J. H. Memoirs of the Geological Survey. England and Wales. The Geology of the Country around East Dereham. (Water and Well-sections, pp. 51–56.) 8vo. *Lond.*

Colenutt, G. W. The Proposed New Waterworks at West Cowes. *Isle of Wight County Press*, December 8.

De Rance, C. E. On 'Notes on Lancashire Water Supply.' *Trans. San. Inst.* vol. ix. pp. 415–422.

Fordham, H. G. A Record of Water-level in a deep Chalk Well at Barley, Herts, 1864–1886. *Trans. Herts Nat. Hist. Soc.* vol. v. pt. i. pp. 20–22, pl. i.

Grantham, R. F. Notes on Water Supply, with Special Reference to Villages and Country Mansions. (And Discussion.) *Trans. Surveyors' Inst.* vol. xx. pts. v. vii.

Ormerod, G. W. Notes on Deep Borings at the Waterworks, and in the Trias, at Teignmouth, Devon. *Trans. Devon. Assoc.* vol. xx. pp. 391–397.

Strahan, A. Memoirs of the Geological Survey. England and

Wales. The Geology of the Country around Lincoln. 8vo. *Lond.* (Wells, pp. 193–196, 201–207. Mineral Springs, pp. 208–210.)

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Lovett, E. Report on the New Well at Addington. *Ibid.* pp. 152–154.

Mansergh, J. Reading Water. Report to the Mayor and Corporation of Reading. Pp. 28. Fol. *Reading.* (Also Discussion at the Conference, pp. 23.)

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—— Hampshire Well-sections. *Hants Field Club. Papers,* no. 3, pp. 17–36.

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De Rance, C. E. Subsidence at Wybunbury, near Crewe. *Ibid.* pp. 197–199.

—— Notes on Borings for Water and Salt in the County of York. *Proc. Yorksh. Geol. Soc.* n. series, vol. xi. pt. 3, p. 424.

Harker, Professor A. On the Geology of Cirencester Town, and a recent discovery of the Oxford Clay in a deep well boring at the Water Works. *Proc. Cotteswold Club*, vol. 10, pt. 2, p. 178.

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Cetiosaurus *Remains.—Report of the Committee, consisting of* Professor A. H. GREEN (*Chairman*), Mr. JAMES PARKER (*Secretary*), *the* EARL of DUCIE, Professor E. RAY LANKESTER, *and* Professor H. G. SEELEY, *appointed to examine the Ground from which the Remains of the* Cetiosaurus *in the Oxford Museum were obtained, with a View to determining whether other parts of the same Animal remain in the Rock.*

THE Committee have to report that from unavoidable circumstances no satisfactory conclusion has as yet been arrived at.

During the Easter vacation, when excavations might have been made, their Chairman, Professor A. H. Green, was prevented by illness from taking any active part, and therefore no orders could be given for actual operations in the way of digging. Several visits, however, have been made to the spot and information obtained; and, further, full permission has been obtained from Lord Valentia, the owner of the land, to make such excavations as are required, and co-operation from his agent has also been promised.

The quarry where the bones were found is in a slope facing the north, and to the south of the spot where it has been ascertained they lay, further excavations would be attended with much difficulty, as the ground rises rapidly some 20 feet and is surmounted by a wall, on the other side of which there is a high road, and excavations might endanger its stability.

On the western side, where it was thought most advisable to excavate, it was at the last moment discovered that some two or three years previously some excavations had been undertaken with the same object, but without success, and then filled up again. As to reopening and extending these, a decision cannot be come to till further particulars as to what was done are obtained and the men found who were employed. On the eastern side there is perhaps more chance of success, but the ground here also has at some time been evidently much broken up.

Meanwhile, however, the opening of a quarry about 350 yards to the south has disclosed the circumstances that the sandy bed, which contained the bones of the Cetiosaurus and which also contains much carbonaceous matter, is continued in this direction. The pit where the bones were found is on the northern edge of a promontory round which the Cherwell river runs, and the quarry lately opened is practically on the south edge of the same promontory. The bed is of the same thickness, namely, from 6 to 12 inches, and appears from the measurements at present taken to be almost exactly at the same level in each spot, and in each case resting upon some 20 feet of limestone beds belonging to the Great Oolite. Most of these beds are very hard and more or less fossiliferous, but one or two very soft. One soft bed, about 6 feet below this sandy parting, is crowded with *Terebratula maxillata*. This bed is found in one or two other sections not far distant, and forms a definite datum line in the several sections for comparison.

Above the sandy parting, in both the Cetiosaurus pit and the newly opened pit, there is a bed of about 4 feet of shale, immediately followed by the hard slabs and slaty beds of the Forest Marble.

This 6 to 12 inch sandy bed, with the carbonaceous matter in which the bones were found, may be certainly taken as the line of demarcation between the Great Oolite and the Forest Marble; and though there is no trace of unconformity (the beds being all practically horizontal), the sudden change in lithological character points to a marked change of physical circumstances, in which the surface, if not actually becoming dry land, must have become nearly so, to be followed again by the shales and the marine beds of the Forest Marble.

This change may perhaps account for so many bones of one individual animal being found together and comparatively so little worn by any movement whatever.

Some 400 yards to the east, and about the centre of the promontory, large quarries are open, which pass through 25 feet of the Cornbrash and Forest Marble, apparently reaching the shales which rest on the sandy parting referred to, as shown in the other sections. Though there is no reason to anticipate that any of the bones of this particular animal may have been drifted in this direction, it is thought advisable to make an excavation or so at the place with the view of ascertaining exactly how far the particular sandy parting is extended.

In the uncertainty as to which was the best spot where to set the excavations going, the Chairman felt he was not justified in drawing any money on account of the grant of 20*l.*; but now that permission has been granted and several observations and measurements made and inquiries set on foot, the Committee would request that the grant may be renewed, so that the inquiries and observations may be continued, and that at the first favourable opportunity some trial holes may be made, partly with a view of being satisfied that no further remains of that animal exist near the spot where the others were found, partly also of determining somewhat further than has been done the circumstances under which those remains were deposited in that spot, and the relation of the bed in which they occur to the Great Oolite below and the Forest Marble above.

Photographs of Geological Interest in the United Kingdom.—Sixth Report of the Committee, consisting of Professor JAMES GEIKIE (*Chairman*), Professor T. G. BONNEY, Dr. TEMPEST ANDERSON, *the late* Dr. VALENTINE BALL, Mr. JAMES E. BEDFORD, Professor W. BOYD DAWKINS, Mr. EDMUND J. GARWOOD, Mr. J. G. GOODCHILD, Mr. WILLIAM GRAY, Mr. ROBERT KIDSTON, Professor T. MCKENNY HUGHES, Mr. A. S. REID, Mr. J. J. H. TEALL, Mr. R. H. TIDDEMAN, Mr. W. W. WATTS, Mr. H. B. WOODWARD, *and* Mr. OSMUND W. JEFFS (*Secretary*). (*Drawn up by the Secretary.*)

YOUR Committee have the honour to report that during the past year 161 photographs have been received, thus bringing up the number registered since the commencement of their operations to a total of 1,216. Particulars of the new additions are, as heretofore, given in this Report. By far the greater number of these are the work of Mr. Godfrey Bingley, of Leeds, to whom the Committee are indebted for much valuable assistance. They desire to record their thanks to the following donors of photographs and others who have rendered aid in various ways: Professor

Bonney, Messrs. J. E. Bedford, Godfrey Bingley, F. W. Broadhead, Montagu Browne, F. N. Eaton, W. Gray, S. Hey, R. Kidston, J. G. McDakin, G. A. Piquet, T. Mellard Reade, A. S. Reid, Aubrey Strahan, J. J. H. Teall, Beeby Thompson, and W. W. Watts; the Geologists' Association (of London), the Leeds Geological Association, the Belfast Naturalists' Field Club, the Dover Natural History and Antiquarian Society, and the Yorkshire Geological and Polytechnic Society.

Following the usual practice, a summary of the geographical areas represented in the collection is given below:—

NEW ADDITIONS (1895).

ENGLAND AND WALES:		
Carnarvon	4	
Cornwall	25	
Devonshire	8	
Kent	1	
Lancashire	1	
Leicestershire	4	
Staffordshire	4	
Yorkshire	42	
	—	89
CHANNEL ISLANDS		5
SCOTLAND:		
Forfarshire	7	
Stirling	7	
	—	14
IRELAND:		
Antrim	27	
Donegal	3	
	—	30
MICROSCOPIC SECTION		2 3
Total		161

GENERAL SUMMARY.

England and Wales	774
Scotland	139
Ireland	236
Channel Islands	9
Isle of Man	23
Microscopical sections	35
Total	1,216

The above number comprises several duplicates, the same section or locality having in some cases been photographed by different persons. It was decided to record all prints received, but it will be readily understood that in so large a number, from so many sources, a proportion of the prints sent in has been found, on examination, to be unsuitable—either as not coming within the scope of the collection, or, from want of definition or other causes, not being sufficiently good examples of features of geological interest. It is further to be regretted that several prints have been sent in without the needful explanatory details to show what the photograph was intended to illustrate. It will be necessary, in arranging the collection in its permanent location, for a careful inspection to be made in order that prints which are found to be unsuitable may be eliminated. The necessity for the use of a permanent process of printin copies from negatives is seen in the fact that some of the prints received at an early period of the collection have faded. In many cases, too, the earlier photographs have been replaced by better prints of the same subject. From these and other causes, the number of photographs which have been mounted and placed in the portfolios provided by the Committee is somewhat less than that given in the above summary.

The Committee have made special efforts during the year to obtain contributions of photographs from localities not hitherto represented in the collection, and have again issued a circular to the delegates of the Corresponding Societies and to a large body of geologists and photographers in the United Kingdom. All the responses which were expected have not yet been received, owing, in great measure, to the fact that it is often difficult (especially in those of our inland districts situated far away from large towns) to obtain the services of a skilled photographer having sufficient geological knowledge.

In addition to the usual recommendations for the collection of photographs, the Committee issued a *précis* (given below) of the letters containing suggestions for suitable cameras sent by several members who were invited to state their views on this subject, as mentioned in the last Report. It is hoped that these hints on the selection of a suitable camera for geological field work may be useful to many geologists who desire to have their own photographic records of scenic features or sections of interest.

Apparatus for Geological Photography.

The *best* camera to use is probably that to which the worker is himself most accustomed. These hints are added for the guidance of those who have not yet adopted any particular camera.

The camera should be as light as possible, but *rigidity* when set up is absolutely necessary.

Double swing-back and rising and falling front are essentials, to allow of correct perspective and the true rendering of lines and curves.

The camera should admit of long extension to permit the use of lenses of various *foci*.

It is sometimes desirable to take photographs of inclined or horizontal rock-surfaces at distances of a few feet, for the purpose of showing minor features, such as veins, glacial markings, structures of gneissose rocks, &c. To effect this, two boards hinged together with some arrangement for fixing them at the desired angle are all that are required. The lower board must, of course, be screwed to the stand and the upper one to the camera.

A spirit level should be attached to or used with the camera.

It is well to have three lenses :—(1) A rapid rectilinear doublet of 10 to 12-inch focus (for $\frac{1}{2}$-plate size) ; (2) a wide-angle meniscus, focal length about 6 to 7 inches, for interiors of quarries and craters ; and (3) a long-focus lens of focal length equal to three or four times the length of the plate, for distant hills and inaccessible cliffs.

If only one lens is used, it should be a rapid rectilinear of about 9-inch focal length (for $\frac{1}{2}$-plate size), and should be by some reputable maker. It must be the best of its kind obtainable. Though films materially decrease the weight to be carried, they are not recommended for general use : plates should be used whenever possible. Good general work can be done with a $\frac{1}{4}$-plate or five by four camera, and subsequent enlargement on bromide paper. In this case it is essential that the lens should be of first-rate make. For direct printing, the cold-bath platinotype method is recommended as the most permanent; it is now very easy to work.

It is advisable, when measurements are unattainable, that a 'scale object' should be included in the photograph. (A hammer is sometimes used, but it is not suitable.)

ARTHUR S. REID,
AUBREY STRAHAN,
J. J. H. TEALL,
WILLIAM GRAY.
(Referees appointed by the Committee to make the *précis.*)

The Council of the Association having approved of the recommendation to deposit the collection of photographs at the Museum of Practical Geology, Jermyn Street, London,[1] the work of arranging the photographs preparatory to their reception at the Museum was commenced. It was expected that the collection would be deposited in its permanent home early in the present year; but the work of mounting and arranging was unavoidably delayed, and when this could be proceeded with, the Secretary found himself unable, through unexpected calls upon his time, to undertake the necessary supervision and to complete the work at the date originally intended. These unforeseen difficulties have now, however, been overcome, and the first portion of the collection, consisting of five portfolios and fourteen cases, containing some 886 photographs (as given in the Schedule, Appendix I.), has now been delivered at Jermyn Street. The remainder will be completed and forwarded to the Museum as soon as possible after the conclusion of the meeting at Ipswich.

The Committee desire to record their deep sense of the loss sustained through the death of their esteemed colleague, Professor Valentine Ball, C.B., F.R.S., whose active and valuable assistance in furthering the objects of the Committee was most highly appreciated.

Now that the collection of geological photographs has found a permanent home, where, in due time, it will be accessible to the public, the Committee are desirous of pushing their work forward as rapidly as possible. There is still, however, much to be done before the collection can be said to be truly representative, in a pictorial sense, of the leading outlines of British geology. Important sections are being frequently opened, of which it is often useful to preserve photographic record, and the large area from which no photographs have yet been sent in points to the desirability of the continuance of systematic effort to obtain a more complete series of geological illustrations.

It is, moreover, felt that the value and utility of the collection would be greatly increased by the publication of a supplementary catalogue having a geological arrangement. Should the Committee be reappointed for another year, it is not desired to apply this year for a renewal of the grant.

SIXTH LIST OF GEOLOGICAL PHOTOGRAPHS.

(TO AUGUST 1895.)

NOTE.—This list contains the subjects of geological photographs, copies of which have been received by the Secretary of the Committee

[1] See last year's Report.

since the publication of the last Report. Photographers are asked to affix the registered numbers, as given below, to their negatives for convenience of future reference.

Copies of photographs desired can, in most instances, be obtained either from the photographer direct or from the officers of the local society under whose auspices the views were taken.

The price at which copies may be obtained depends upon the size of the print and local circumstances, over which the Committee have no control.

The Committee find it necessary to reiterate the fact that they do not assume the copyright of any photographs included in this list. Inquiries respecting them, and applications for permission to reproduce photographs, should *not* be addressed to the Committee, but to the photographer direct.

[*E. signifies Enlargements.*]

ENGLAND AND WALES.

CARNARVONSHIRE.—*Photographed by* G. T. ATCHISON, *Corndon, Sutton, Surrey. Size* $8\frac{1}{2} \times 6\frac{1}{2}$ *inches.* (*E.*)

Regd. No.		
1190	Cwm Glas, Snowdon	Glaciated Bala Rocks
1191	Black Rock, Criccieth	Caves in Tremadoc Rocks
1192	,, ,,	Caves in Tremadoc Rocks
1193	,, ,,	Junction of Tremadoc Rocks and sill of Dolerite

CORNWALL.—*Photographed by* GODFREY BINGLEY, *Headingley, Leeds.* (*Per Leeds Geological Association.*) *Size* 6 × 4 *inches.*

1068, 1069, 1099, 1100	Bude	Millstone grit
1070–1072, 1090	Boscastle, Pelly Point	Island and cliffs
1073, 1074	Boscastle, Wallapark Pt.	Slates, grits, and quartz veins
1075, 1076	,, Entrance to Harbour	,, ,,
1091	Boscastle, Pelly Point	,, ,,
1092–1096	,, ,,	View of coast
1082, 1087, 1088	Tintagel, Castle Cove	General view
1083–1086	,, ,,	Rocky valley
1089	,, ,,	View of coast, looking south-west

DEVON.—*Photographed by* GODFREY BINGLEY, *Headingley, Leeds.* (*Per Leeds Geological Association.*) *Size* 6 × 4 *inches.*

1077–1079, 1101	Lynton	Strata at Castle Rock
1080	Ilfracombe, Hillsborough	Argillaceous slate
1081, 1097	,, Capstone Hill	,, ,,
1098	,, Lantern Hill	,, ,,

KENT.—*Photographed by* Captain J. G. MCDAKIN, 15 *Esplanade, Dover.* (*Per Dover Natural History and Antiquarian Society.*) *Size* 8 × 6 *inches.* (*E.*)

1056	Dover ($1\frac{3}{4}$ miles east of)	Fall of Cobler Cliff, Middle Chalk

LANCASHIRE.—*Photographed by* S. HEY, *Dane Street, Rochdale. Size* 10×8 *inches.*

Regd. No.		
1062	Sparth Bottom, Rochdale	Fossil tree in shale (upright as found)

LEICESTER.—*Photographed by* W. F. BROADHEAD, *Leicester. Size* 10×8 *inches.*

1058, 1059	Bardon Hill . . .	Quarry in felstone
1060	Markfield . . .	„ syenite
1061	Sheepshed . . .	„ „

STAFFORD.—*Photographed by* C. C. HOWARTH, *Holden Road, Blundellsands, Lancashire.* (*Per T. Mellard Reade, F.G.S.*) *Size* 6×4 *inches.*

1179–1182	Cannock Chase . .	'Pitted' pebbles, from Bunter conglomerates

YORK.—*Photographed by* GODFREY BINGLEY, *Headingley, Leeds.* (*Per Yorkshire Geological and Polytechnic Society.*) *Size* 11½×9½ *inches.* (*E.*)

1057	Filey, Carr Naze . .	Rain-weathering shown in cliffs of Boulder Clay (3105)

(*Per Leeds Geological Association.*) *Size* 6×4 *inches.*

1109	Malham Cove . .	Carboniferous Limestone
1110, 1111	„ Gordale Scar	„ „
1112	Clapham, entrance to Ingleborough Cave	„ „
1113	Bolton Abbey, R. Wharfe	Anticlinal in Yoredale Shales
1114, 1115	Ilkley, 'Cow and Calf' Rocks	Millstone grit
1116–1118	Filey	Denuded cliffs of Boulder Clay
1119–1121, 1128, 1122–1124	Filey, The Brigg . .	Coralline Oolite and Calcareous Grits capped by Boulder Clay
1125	Scarborough . . .	Carbonaceous grits
1126	Leeds, Rowley's Quarry, Headingley	Gannister beds
1127	Leeds	Lower Carboniferous beds
1129, 1130	Flamborough, Thornwick Bay	Chalk
1131, 1132	Flamborough, Thornwick Bay (north of)	„
1133	Flamborough, Thornwick Bay (south of)	„
1134–1137	Flamborough, Thornwick Bay	„
1138	Flamborough, North Landing	„
1139	Flamborough, 'The Giant's Leg'	Denudation of Chalk
1140	Flamborough, 'King and Queen Rocks'	„ „
1141, 1142	Flamborough, Silex Bay	„ „
1143–1145	„ view near Lighthouse	Chalk cliffs
1146, 1147	Clapham, Trow Gill .	Denuded channel in Carboniferous Limestone
1178	Barnard Castle, Deepdale	Erratic boulder of Shap Granite lying on Yoredale rocks

CHANNEL ISLANDS.—*Photographed by* G. A. PIQUET, 68 *New St. John's Road, Jersey. Size* 8 × 6 *inches.*

Regd. No.		
1063	St. Quens . . .	Sea-worn boulders in roof of cave near Creux Gabourel
1064, 1065	„ 'La Pinnacle'.	Denudation of granite stack
1066	St. Mary's, Jersey . .	Rocky gorge
1076	Sorel Point, St. John's .	Pool in granite

SCOTLAND.

FORFARSHIRE.—*Photographed by* GODFREY BINGLEY, *Headingley, Leeds.* (*Per Leeds Geological Association.*) *Size* 6 × 4 *inches.*

1102–1108	Arbroath . . .	Sections in Old Red Sandstone

STIRLING.—*Photographed by* R. KIDSTON, *F.R.S.E.*, 24 *Victoria Place, Stirling. Size various.*

1183–1186	Cambusburran (sand pit on 100 ft. beach)	False bedding and gravel pit in sand
1187	Ballengrich quarry . .	Spheroidal weathering of dolerite
1188	„ „ . .	Glacial striæ on dolerite
1189	Goats' Mount, Sandric Crag	Dolerite lying on altered shales

IRELAND.

CO. ANTRIM.—*Photographed by* GODFREY BINGLEY, *Headingley, Leeds.* (*Per Leeds Geological Association.*) *Size* 6 × 4 *inches.*

Regd. No.			
1148	Portrush, 'The Wash Tub'		Basalt
1149	Cliffs from Dunluce Castle		„
1150	Cliffs from White Rock		Chalk
1151, 1152	Dunluce to Portrush		Chalk and basalt
1153, 1156–1158	Portrush, Giant's Head		„ „
1154	The White Rocks, Giant's Head		„ „
1155	Giant's Causeway, The Honeycomb		Basalt
1159, 1160	Giant's Causeway		Columnar basalt
1161–1163	„	The Loom	„ „
1164	„	Gateway	„ „
1165, 1166	„	Chimney Stacks	„ „
1167, 1168	„	Grand Causeway	„ „
1164–1170	„	Chimney Tops	„ „
1171, 1172	„	Portnabo	Dolerite dyke
1173, 1174	„	Benanouran Head	Basalt

CO. DONEGAL

1175, 1177	Killybegs . . .	General view
1176	Donegal	„ „

MICROSCOPIC ROCK SECTIONS.—*Photographed by* W. W. WATTS, 28 *Jermyn Street, S.W. Size* $4\frac{1}{4} \times 3\frac{1}{4}$ *inches.*

1194–1205	Tardree, Sandy Braes, and Templepatrick	Perlitic cracks in the quartz and matrix of a rhyolite

Size 7 × 5 *inches.*

1206–1216	Sulby Glen, &c., Isle of Man .	Sections of the 'Crush Conglomerates' and associated rocks

APPENDIX I.

Schedule of the collection of Photographs of Geological Interest, as arranged by the Committee appointed by the British Association, forwarded (in accordance with a resolution of the Council) to the Director-General of the Geological Survey, to be deposited in the Museum of Practical Geology, 28 Jermyn Street, London.

Arrangement of the Collection of Geological Photographs.

Note.—The Committee appointed to undertake the 'collection, preservation, and systematic registration of photographs of geological interest in the United Kingdom' began its operations in 1889. During the first two years prints were received mounted on cards without restriction as to size. Afterwards, to secure uniformity, a standard mount was adopted, with perforated edges for binding in cases (size $15\frac{1}{2} \times 12$ inches). It was not found practicable to transfer the early portion of the collection to the standard-sized mounts in cases. The arrangement of this portion has therefore had to be made in portfolios, boxes and cases of various sizes. When the size is not stated it will be understood that the cases consist of the *standard-sized mounts*, measuring $15\frac{1}{2} \times 12$ inches.

Inventory.—The following are on irregular sized mounts, dimensions of the *largest* mounts being given below:—

CONTENTS.

Miscellaneous (I.) *Size up to* 21 × 18 *inches.*

Description of Case, &c.		No. of Photographs in Case, &c.
Part 1. (Cloth Case.)	(*a*) Series of Mr. G. H. Morton, illustrating the Carboniferous limestone of Llangollen. (*b*) Series of the Yorkshire Geological and Polytechnic Society. (*c*) Series of the Leicester Literary and Philosophical Society (2). (*d*) Series of Mr. Ussher, illustrating the granite structures of Dartmoor, &c. (*e*) Chalk, Co. Antrim (enlargements), by Miss M. K. Andrews	38

Northumberland and Durham (I.) *Size up to* 14×10 *inches.*

Part 2. (Cloth Case.)	Mr. E. J. Garwood's (First) Series, illustrating Sections in Coal Measures, &c.	14

Lancashire and Cheshire. *Size* 14×11 *inches.*

Part 3. (Cloth Case.)	Series of the Liverpool Geological Society and the Leeds Geological Association, &c.	44

North Wales and Isle of Man (I.) *Size* 14×12 *inches.*

Part 4. (Portfolio.)	Series of the Liverpool Geological Society, Leeds Geological Association, and Mr. A. O. Walker	36

Ireland (I.) *Size* 12×10 *inches*

Part 5. (Portfolio.)	(*a*) Series of Professor V. Ball, illustrating the Cambrian quartzites and Boulder beds, drift on Cambrian rocks of Howth, Carboniferous Limestone, &c. (*b*) Series of Miss Andrews, illustrating Chalk at Kenbane Point, Antrim basalts and granite boulders, Newcastle . .	25

Yorkshire (I.) *Size* 13 × 10 *inches.*

Description of Case, &c.		No. of Photographs in Case, &c.
Part 6. (Portfolio.)	(*a*) Series of the Leeds Geological Association. (*b*) Series of Mr. J. W. Woodall, illustrating effects of recent floods on Chalk	60

Miscellaneous (II.)—Southern Counties. *Size* 17 × 12 *inches.*

Part 7. (Portfolio.)	(*a*) Series of East Kent Natural History Society, illustrating Thanet beds and Chalk of the Elham Valley. (*b*) Views and Sections in Devon, Surrey, Somerset, Berks, and Wilts	24

Scotland (I.) *Size* 13 × 10 *inches.*

Part 8. (Portfolio.)	(*a*) Series of Professor Heddle and J. A. Harvie Brown, illustrating Caithness, Island of Mull, &c. (*b*) St. Kilda: Weathering of volcanic rocks (*c*) Stigmarian roots at Partick	32

Miscellaneous (III.) *Size* 16 × 14 *inches.*

Part 9. (Box.)	Series of Mr. J. J. Cole, F.R.A.S., illustrating sections in Dorset, Devon, Cornwall, and the Snowdonian region, North Wales	18

Miscellaneous (IV.) $\frac{1}{4}$-plate and $\frac{1}{2}$-plate Photos. *Size* 9 × 5 *inches.*

Part 10. (Case.)	(*a*) Microscopic Sections of Phosphatic Chalk, Taplow. (*b*) Saurian footprints from the Cheshire Trias. (*c*) Sections in vicinity of the Manchester Ship Canal. (*d*) Views in Dorset. (*e*) Views in Nottingham and Derbyshire	41

The following are all on standard-sized mounts:—

Northumberland and Durham (II.)

Part 11. (Case.)	(*a*) Mr. Garwood's Second Series, illustrating Whin Sill, Teesdale, &c. (*b*) Mr. G. Hingley's Series, Marsden Bay, &c.	34

Yorkshire (II.)

Part 12. (Case.)	Series of the Leeds Geological Association and others . .	111

Ireland (II.)—Co. Antrim.

Part 13. (Case.)	Series of Dr. Tempest Anderson, Mr. W. Gray, the Belfast Naturalists' Field Club, Miss M. K. Andrews, and Mr. R. Welch	84

Ireland (III.)

Part 14. (Case.)	Series of Miss Andrews, Mr. W. Gray, Belfast Naturalists' Field Club, &c., illustrating counties Londonderry, Down, Donegal, Fermanagh, Clare, and Cork	67

Scotland (II.)

Description of Case, &c.		No. of Photographs in Case, &c.
Part 15. (Case.)	Series of Messrs. Valentine, illustrating Staffa and Skye. Series of Mr. W. Lamont Howie, illustrating Pillars of Old Red Conglomerate, Morayshire (and Earth Pillars of the Tyrol), the Scottish Highlands. Series of the Perthshire Society of Natural Science. Series of Mr. Wilbert Goodchild, illustrating Sections in the vicinity of Edinburgh, &c.	54

North and South Wales and Isle of Man (II.)

Part 16. (Case.)	Series of Mr. W. W. Watts, Mr. C. J. Alford, the Manchester Geographical Society, &c., and of Mr. F. J. Eaton (Isle of Man).	

Cheshire, Derbyshire, Shropshire, and Monmouth.

Part 17. (Case.)	Series of Mr. W. W. Watts, Manchester Geographical Society, and others	54

Middlesex, Berks, Herts, Stafford, Warwick, and Worcester.

Part 18. (Case.)	Illustrating various Sections at Tewkesbury, St. Albans, Nuneaton, &c.	26

Dorset, Kent, Hants, Cornwall, and Surrey.

Part 19. (Case.)	Series of East Kent and Dover Natural History Society and others, illustrating various Sections, &c., and groups of bone and flint implements and teeth, from Kent's Cavern, Torquay (Mr. A. R. Hunt)	81
	Total	886

APPENDIX II.

Reference List of Photographs illustrating Geological Papers and Memoirs.

Geologists' Association. 'Proceedings.' Vol. XIII., Part 9. *August*, 1894. Illustrating Paper on 'The Geology of South Shropshire,' by Professor C. Lapworth, LL.D., F.R.S., and W. W. Watts, M.A., F.G.S. (From Negative by Rev. J. MacLeod, of Hope.)

Regd. No.		
	View of Roundtain, looking North	Arenig Lava. (From Negatives by W. W. Watts, M.A.)
87	E. Crags, of Todleth	Columnar Andesite
84	Quarry at Tasgar	Upper Arenig ash-bed, with fossiliferous shales at base
435	Section at Hope Rectory	Contorted ash-bed in Middle Arenig shales
80	Section at Hope Dingle	Hope shales and ash-beds; Llandovery shales
436	Road cutting, Wenlock Edge	Wenlock Limestone

Geological Magazine, Dec. 10, *Vol. II.*, 1894. Plate XL. (From Negatives by C. C. Howarth.)

1179–1182	Cannock Chase	'Pitted' pebbles from Bunter Conglomerates

Geological Society. 'Quarterly Journal.' Vol. L., 1894. Plate XVIII. and page 371. Figs. 1–6. (From Negatives by W. W. WATTS.)

1194–1205 Tardree, Sandy Braes, &c. . Perlitic cracks in Quartz

Geological Society. 'Quarterly Journal.' Vol. LI., 1895. Plates XX. and XXI. (From Negatives by W. W. WATTS.)

1206–1215 Sulby Glen, &c., Isle of Man — Microscopic sections of 'Crush Conglomerates'

Hertfordshire Natural History Society. 'Transactions.' Vol. VII., Part 8. *February* 1894. Illustrating Report on Field Meetings of the Society, by JOHN HOPKINSON, F.G.S.

Photographed by Mr. HOPKINSON.

733 St. Albans — Section on Midland Railway — Chalk, Tertiaries, and Drift
734 St. Albans . . . Section of Hertfordshire Conglomerate

Liverpool Geological Association. 'Journal.' Vol. XIV., 1893–94. Illustrating Paper on 'The Fossil Footprints of Storeton,' by OSMUND W. JEFFS. (From Negatives by F. N. EATON.)

741–746 Slabs of sandstone, from the Keuper of Storeton, Cheshire, showing various types of saurian footprints (3 plates, 6 photographs).

Stonesfield Slate.—Second Report of the Committee, consisting of Mr. H. B. WOODWARD (*Chairman*), Mr. E. A. WALFORD (*Secretary*), Professor A. H. GREEN, Dr. H. WOODWARD, *and* Mr. J. WINDOES, *appointed to open further sections in the neighbourhood of Stonesfield in order to show the relationship of the Stonesfield slate to the underlying and overlying strata.* (*Drawn up by* Mr. EDWIN A. WALFORD, *Secretary.*)

THE shaft sunk by the Committee in 1894 was reported by the workmen to be unsafe, and an unsuccessful attempt was made to find the old sinking of 1830 at Reed Hill, near Stonesfield, reported upon by Professor Ed. Hull. The work was ultimately continued upon the Stocky Bank shaft to a depth of 60 feet. At that depth it had penetrated 13 feet into one of the highest beds of the Inferior Oolite—the Clypeus-Grit (zone *Ammonites Parkinsoni*). It has proved the continuance not only of the compact barren limestones (sub-Bathonian) so well developed around Chipping Norton, but also of the sandy limestone beds between them and the Clypeus-Grit.

The section, as before stated, has been made by scarping a bank for about 30 feet, and by sinking a shaft to a depth of 60 feet on the step of the bank. It is practically a continuous section, only 2 or 3 feet intervening, laterally, between the ending of the one cut and the beginning of the other.

Section at Stocky Bank, Stonesfield, from the Great Oolite coral beds to the Inferior Oolite, showing position of Stonesfield Slate series and Chipping Norton limestones.

No.	Beds	Ft.	in.	Ft.	in.
1.	Surface soil with Limestone fragments. *Nerinæa*, Corals, *Thamnastræa Lyellii*, *Isastræa limitata*, *Cryptocœnia Prattii*, &c. 'Rift Bed'			0	9
2, 3.	Marls and Limestone, with Oysters and *Rhynchonella concinna*			6	0
4.	Limestone, cream colour, shelly and compact			6	0
5–9.	Marls and Limestone, five beds with Oysters and *Rhynchonella*			5	2
10–13.	Stonesfield Slate beds:—				
	Roof-shelly Limestone	1	8		
	Top hard-shelly Limestone	0	7		
	Pendle-Sandstone	1	0		
	Floor-fissile Limestone	2	0	5	3
14, 15.	Limestone, with thin Marl parting a top			2	6
16.	Fissile Sandstone			0	5
17, 18.	Fawn colour, sandy, and oolitic Limestone			13	0
19.	Clay			1	6
20.	Limestone, buff colour			2	8
21, 22.	Limestone, with Marl parting a top, *Mytilus Sowerbyanus*, *Rhynchonella concinna*, *Ostrea Sowerbyi*			1	7
23.	Black Clay, crowded with *Placunopsis* and with *Perna*, *Nucula*, and *Ostrea*			1	7
24.	Shelly Limestone made up of fragments of *Ostrea*, passing into a brown Limestone, blue hearted, crowded with shells, *Perna quadrata*, *Cyprina*, *Corbula*, *Macrodon*, &c.			2	0
25.	Black Clay			0	11
26.	Roe stone, an oolitic stone, blue hearted, made up of whitish oolites in blue or brown base (like the blue oolitic slate)			1 to 2	0
27.	'Callous' Limestone—stone in fragments cemented together			1	0
28.	Bastard Freestone, fine grained, oolitic, with masses of fossil wood			1	3
29.	Buff and brown Marly Rubble, with carbonaceous markings and remains of shells, *Cyprina*, &c.			0	9
30.	Bastard Freestone, cream coloured, without plant remains			2	0
31.	Bastard Freestone, with black dendritic markings			2	0
32.	Freestone of poor quality, splintery, more distinctly oolitic than beds 30 and 31			4	0
33.	Sandy Limestone, fine-grained, blue-hearted, oolitic			4	0
34.	Grey, blue and brown Marls, with Oysters and fossil wood in lower part			3	0
35.	Limestone, shelly, oolitic, cream-coloured and fine-grained, pale blue centres, and with brown vertical markings			4	0
36.	Rubble with ochreous patches and carbonaceous markings			0	9
37.	Clypeus-grit; a coarsely oolitic rubbly Limestone with *Clypeus Plotii*, pinkish in upper part			13	0

(About 12 feet of stone can be made out below.)

Whether beds 16 to 26 are in their proper place is open to doubt. They contain fossils (excepting corals) similar to those found in the railway cutting at Ashford Bridge, barely a mile distant, and the clay courses are alike. Many authors report the slate to underlie the carbonaceous clays and coral bed in the Ashford Bridge cutting. The Stocky Bank is much faulted.

In the open section at Reed Hill, as described by Mr. H. B. Woodward, the slate is covered by 5 feet of marls with *Modiola gibbosa*, *Rhynchonella concinna*, and *Ostrea Sowerbyi*. In the Stocky Bank section, in the near shafts, and in other open workings, the succession of strata is the same.

In order to consider more fully the true position of the beds 16 to 26 and to study relative sections and their fossil contents, your Committee would defer the final report until 1896.

The Fossil Phyllopoda of the Palæozoic Rocks.—Twelfth Report of the Committee, consisting of Professor T. WILTSHIRE (*Chairman*), Dr. H. WOODWARD, *and* Professor T. RUPERT JONES (*Secretary*). (*Drawn up by* Professor T. RUPERT JONES.)

1§. A SHORT provisional list of the Silurian *Peltate* Phyllopods was appended to our Report (the Tenth) for 1893; but since then a complete catalogue of the Lower Palæozoic Phyllopoda (Phyllocarida), with their geological horizons, their range and localities, has been made with the obliging help of Dr. C. Lapworth, F.R.S. This is now produced in four tables, as it greatly enhances the value of our Reports on these fossils, and will be of considerable use to palæontologists both at home and abroad.

TABLE I.—*List of the Genera and Species of the Lower Palæozoic Phyllopoda referred to by* T. RUPERT JONES *and* H. WOODWARD *in their Reports to the British Association*, 1883–94.

(*The figures at end of lines refer to pages in the 'Monogr. British Palæozoic Phyllopoda,' Palæont. Soc.*, Part II., 1892.)

Hymenocaris vermicauda, Salter	74–79
Lower Lingula-flags.—Pentre'r felin, west of Penmorfa	77
„ „ Gareg-felen	77, 79
„ „ Bryntwr Summerhouse	77
„ „ Moel-y-gest, hill behind Portmadoc (? Tremadoc)	77, 79
„ „ Wern, near Penmorfa, near Tremadoc	77
„ „ (Upper part of).—Cae'n-y-coed, near Maentwrog	79
„ „ Gwern-y-barcud	77
Middle Lingula-flags.—Borth, Portmadoc	78
„ „ Ffestiniog	77
„ „ Wern, cutting near. G. J. Williams.	
Upper Lingula-flags.—Moel-hafod-Owen, near Dolgelly	77
Upper Tremadoc-flags.—Garth Hill, near Portmadoc	77
Pont Seiont Shales.—Pont Seiont, Caernarvon	77
H. lata, Salter	79, 80
Upper Tremadoc Group.—Garth, Portmadoc.	
Lingulocaris lingulæcomes, Salter	81
Upper Tremadoc Slates.—Garth, Portmadoc.	
Upper Llandeilo Beds, near Builth.	
L. siliquiformis, Jones	82
Upper Tremadoc Series.—Garth, Portmadoc.	
Bala Rocks.—Bwlch-y-gaseg, near Cynwyd, Corwen.	
L. Salteriana, T. R. Jones and H. Woodward	82, 83
Lower Lingula-flags (upper part).—Cae'n-y-coed, near Maentwrog.	
Lower Tremadoc Slate Series.—Tu-hwant-i'r-bwlch Quarry, Portmadoc.	
? Brathay Flags.—E. side of Long Skeddale	
L. sp.	83
Schiste Ardoisier inférieur (Faune 2nde).—Maine-et-Loire.	

Saccocaris major, Salter 84, 85
Lower Lingula—flags (upper part).—Cae'n-y-coed, near Maentwrog.
Upper Tremadoc Slates (small individual).—Tu-hwnt-i'r-bwlch.

S. minor, T. R. J. and H. W. 86–88
? Lower Lingula—flags.—Wern, near Portmadoc.
Upper Arenig Slates (Daear-fawr Shale).—Craig-yr-hyrddod, Arenig.

Caryocaris Wrightii, Salter 89–91
Skiddaw Slates.—Near Keswick.
Graptolitic Shales of the Ballantrae Rocks.—Bennane Head, Ayrshire.
Pont Seiont Shales.—Nantlle Tramway, near Pont Seiont, one mile south-east of Caernarvon.
'Arenig Series' of Huy and Nahnine, Belgium.

C. Marrii, Hicks 92, 93
Skiddaw Slates.—Near Keswick.
Pont Seiont Shales.—Nantlle Tramway, Pont Seiont, one mile S.E. of Caernarvon.

C. Salteri (M'Coy). (See also the Tenth Report, 1893) 93
Llandeilo Series.—Redesdale, Victoria.

Aptychopsis prima, Barrande 100
Étage E (obovate 'prima'; var. 'longa'; oval 'Wilsoni') Limestone.—Bubowitz, Slawick, Wohrada, and Kozel 100, 101
Bohemia (circular 'secunda') Schistose mudstone.—Borek, Litohlow, and Kozel 101, 104

A. Barrandeana, T. R. J. and H. W. 101
Birkhill Shales.—Dobbs Linn, Moffat, Dumfriesshire.
Var. *brevior*, T. R. J. and H. W.—? Birkhill Shales, ? Loc. 102

A. anatina (Salter). (See the Tenth Report, 1893) 103
Lower Wenlock Beds.—Rebecca Hill, Ulverston, Lancashire.

A. lata, T. R. J. and H. W. 104
Gala Group.—From a stream east of Nether Stennies Water, 6½ miles N.N.W. of Langholm, Dumfriesshire.

A. glabra, H. Woodw. 104, 105
Gala Group.—Clovenford, near (W. of) Melrose, Roxburghshire. Collection of the Museum of the Geol. Survey of Scotland.
Buckholm Beds of the Gala Series.—Meigle [hill]; Galashiels, Selkirkshire.

A. Wilsoni, H. Woodward 105, 106
Riccarton Beds.—Shankend, Slitrig Water, near Hawick, Dumfriesshire; Yads Linn, near Hawick; Elliottsfield, near Hawick; Longside Burn, Shankend, Roxburghshire.
Riccarton Graptolite Shales.—Stennies Water, near Langholm, M.G.S.Sc.; Streamlet E. of Nether-Stennies Water, near Langholm, Dumfriesshire, M.G.S.Sc.; Millstone Edge, Teviot Head, Roxburghshire, M.G.S.Sc.

A. Lapworthi, H. Woodward 106–108
Skelgill Beds, or Coniston Mudstones.—Skelgill Beck, near Ambleside, Westmoreland.
Birkhill Shales.—Eldinhope, on the Eldinburn, on the Yarrow, Selkirkshire

Birkhill Shales.—Sundhope Burn, on the Yarrow, Selkirkshire.
„ „ Dobbs Linn, near Moffat.
Red Shale.—Moffat, Dumfriesshire.
Grieston Shales of the Gala Group.—Innerleithen, Peeblesshire, and Selkirkshire.

A. ovata, T. R. J. and H. W. 108, 109
Gala Group.—Stennies Water, 6½ miles N.W. of Langholm, Dumfriesshire.

A. Salteri, H. Woodward 109
Wenlock Shale.—Pencarreg, Caermarthenshire.

A. subquadrata, T. R. J. and H. W. 110
Silurian Beds.—Cloncannon, Tipperary.

A. angulata (Baily) 110, 111
Silurian Beds.—Cloncannon, Tipperary.
Birkhill Shales.—Streamlet, Craigdasher Hill, 4 miles W. by S. of Dunscore, Dumfriesshire.
Brathay Flags.—Nanny Lane, Troutbeck, Windermere, Westmoreland.

A. oblata, T. R. J. and H. W. 111, 112
Riccarton Beds.—Balmangan Bay, west side of Kirkcudbright Bay, Kirkcudbrightshire.
Birkhill Shales.—Dobbs Linn, Moffat.
Gala Group.—Gala Hill, Galashiels, Selkirkshire and Roxburghshire.

Peltocaris aptychoides, Salter 113, 114
Birkhill Shales.—Edinhope, on the Yarrow, Selkirkshire.
Grieston Beds, Gala Group.—Rotten Gair, Innerleithen.
Birkhill Shales.—Duffkennel, Dumfriesshire.
„ „ (Young specimen).—Polmoody, at the top of the Moffat Water, about 13 miles from Moffat, on the road to Dobbs Linn.
„ „ Dobbs Linn, Moffat, Mus. Geol. Surv. Scotl.

P. Marrii, T. R. and H. W.—See the Tenth Report, 1893 . . . . . 114, 115
Skelgill Beds.—West side of Long Sleddale.
Shales (? Birkhill Shales).—? Moffat.
Birkhill Shales.—Whitehope Burn, St. Mary's Loch, Selkirkshire.
Birkhill Group.—Streamlet, Craigdasher Hill, 4 miles W. by S. of Dunscore, Dumfriesshire.
Birkhill Shales.—Garple Glen, 4 miles W. of Moffat.

P. patula, T. R. J. and H. W. 116
Birkhill Shales.—Belcraig, Annandale.
Skelgill Beds.—Skelgill Beck, near Ambleside, Westmoreland.

P. Carruthersii, T. R. J. and H. W. 116, 117
? Birkhill Shales.— ? Near Moffat.
Llandovery Beds.—Tieveshilly, near Portaferry, and Coalpit Bay, Co. Down, N.E. Ireland.
Birkhill Shales.—Dobbs Linn, Moffat.

? *P. Harknessi*, Salter 117
Moffat Shales (? Birkhill).—Dumfriesshire.

Pinnocaris Lapworthi, R. Etheridge, jun. 118
Balclatchie Beds.—Balclatchie, Girvan, Ayrshire.
Upper Silurian Rocks.—Kendal, Westmoreland.

Discinocaris Browniana, H. Woodward 119–121
? Birkhill Shales.—Dumfriesshire.
Birkhill Shales.—Garple Linn, Moffat.
" " Dobbs Linn, Moffat.
Argenteus-Zone, Skelgill Beds.—Lower footbridge, Skelgill Beck, near Ambleside, Westmoreland.
Birkhill Shales.—Dobbs Linn, Moffat.
" " Polmoody, Moffat.

D. ovalis, T. R. J. and H. W. 121, 122
Birkhill Beds.—Dobbs Linn, Moffat.

D. undulata, T. R. J. and H. W. 122
Birkhill Beds.—Garple Burn, Moffat.

D. gigas, H. Woodward 122, 123
Argenteus-Zone, Skelgill Beds.—Skelgill Beck, Ambleside.
Birkhill Shales.—Dobbs Linn, Moffat.

D. Dusliana, Novák.
Étage E–e, 1.—Gross-chucle, S. of Prague, Bohemia.—'Geol. Mag.,' 1892, p. 148.

Caudal Appendages 124
Riccarton beds, pl. xvii. f. 8.—Shankend, Hawick 124
Buckholm beds of the Gala group, pl. xvii. f. 13.—Meigle Hill, Galashiels.—'Monogr. Pal. Soc.,' 1888, Part I. p. 45.
Mudstone of the 'Barren Band,' Skelgill Beds, pl. xvii. f. 12.—Skelgill, Westmoreland 124
Pont Seiont Beds, pl. xvii. f. 9–11.—Nantlle Tramway, near Seiont, Caernarvon 124

Note by Professor C. Lapworth, *LL.D., F.R.S., F.G.S.*

The fossils named in the preceding list are confined to the so-called Lower Palæozoic Rocks, constituting the original 'Silurian System' of Murchison and Barrande, and variously classified by geologists at the present day. All are agreed, however, that they contain three distinct faunas, namely, the 'First, Second, and Third Faunas' of Barrande; but the three distinct series of strata containing these three faunas are variously grouped by different authorities. The French geologists still retain in principle the nomenclature of Barrande, and regard these three rock groups as the three component divisions of the Silurian system, namely, *Silurien Inférieur* or *Primordial*, *Silurien Moyen*, and *Silurien Supérieur*.

The plan adopted in the present notice is to regard each of these three rock series as constituting in itself a distinct system, namely, (A) *Cambrian*, or the System of the First Fauna; (B) *Ordovician*, or the System of the Second Fauna; and (C) *Silurian* (or *Salopian*), or the System of the Third Fauna.

In the following table the various schemes of nomenclature lying between the two extreme types are given for the sake of reference and comparison, and the several formations which have hitherto yielded fossil Phyllopoda (Phyllocarida) are arranged in their natural positions in the general scale of sequence.

TABLE II.—*Showing the Geological Distribution and Vertical Range*
By Professor C. LAPWORTH,

Comparative Nomenclature					
C. STRATA OF THE THIRD FAUNA.	Silurien supérieur	Upper Silurian of Murchison and Geological Survey.	Silurian of Sedgwick.	Upper Silurian of Lyell.	Upper Silurian of Barrande (Lower Half only).
'*Silurian*' *of Sedgwick* (Salopian).					
(C³) *Ludlow Series* (Upper Salopian)					
(*c*) Upper Ludlow and Passage-Beds					
(*b*) Aymestry Limestone					
(*a*) Lower Ludlow Shales					
(C²) *Wenlock Series* (Middle Salopian)					
(*c*) Wenlock Limestone					
(*b*) Wenlock Shales					
(*a*) Woolhope Beds					
(C¹) *Llandovery Series* (Lower Salopian)		Lower Silurian of Murchison and the Geological Survey.			
(*c*) Tarannon Shales					
(*b*) Mayhill or Upper Llandovery					
(*a*) Lower Llandovery					
B. STRATA OF THE SECOND FAUNA.	Silurien moyen of the French authors.		Upper Cambrian of Sedgwick.	Lower Silurian of Lyell (not of Murchison).	Lower Silurian of Barrande.
'*Ordovician*' *of Lapworth, &c.*					
(B³) *Bala or Caradoc Series* (Upper Ordovician) . .					
(*b*) Upper Bala, with *Dicellograptus*					
(*a*) Lower Bala, with *Dicranograptus*					
(B²) *Llandeilo Series* (Middle Ordovician)					
(*b*) Upper Llandeilo, with *Cœnograptus gracilis* .					
(*a*) Lower Llandeilo, with *Didymograptus Murchisoni*					
(B¹) *Arenig Series* (Lower Ordovician)					
(*b*) Upper Division, with *Placoparia*					
(*a*) Lower Division, with *Phyllograptus*					
A. STRATA OF THE FIRST FAUNA.	Silurien inférieur or primordial.		Middle Cambrian of Sedgwick.	Cambrian of Lyell.	Primordial Silurian of Barrande.
'*Cambrian*' *of Lyell.*					
(A³) *Olenidian or Upper Cambrian*					
(*b*) Tremadoc Beds with *Dictyonema* and *Olenus* .					
(*a*) Lingula Flags (of Belt)					
Upper or Dolgelly Beds with *Sphærophthalmus* .					
Middle or Ffestiniog with *Hymenocaris* . .					
Lower or Maentwrog with *Olenellus truncatus* .					
(A²) *Paradoxidian, or Menevian Series, or Middle Cambrian, with Paradoxides Davidis, &c.*					
(A¹) *Taconian, or Olenellus Zone, or Lower Cambrian, with Olenellus, Kutorgina, &c.*					

of the Lower Palæozoic Formations yielding Fossil Phyllopoda.
LL.D., F.R.S., F.G.S.

Horizons yielding Fossil Phyllopoda					
Wales	Lake District	Scotland	Ireland	Bohemia	Other Localities
Venlock Shales.	Brathay Flags.	Riccarton Graptolitic Shales.	Cloncannon (Tipperary)	E 1 Étage, Bohemia.	
	Skelgill Beds.	Grieston Shales and Gala Group.	Treveshilly Beds (County Down)	Bukowitz and Gross Kuchel, &c.	
Corwen Beds.					
Llandeilo Beds of Builth.	Skiddaw Slates, &c.	Balclatchie Beds.			Redesdale (Victoria). Schiste Ardoisier (France). Arenig Series (Belgium).
Pont Seiont Shales.		Bennane Head Shales.			
Portmadoc and Garth Beds. Lingula Flags of Borth, Ffestiniog, and Penmorfa, &c.					

TABLE III.—*Showing the Geological Range of the Genera and Species of the Lower Palæozoic Phyllopoda (Phyllocarida). By* Prof. C. LAPWORTH, *LL.D., F.R.S., F.G.S.*

Genera and Species	Cambrian, or First Fauna: Lower or Olenellus Zone A¹	Middle or Menevian A²	Upper Division or Olenidian A³	Ordovician, or Second Fauna: Lower or Arenig B¹	Middle or Llandeilo B²	Upper Division or Bala B³	Silurian (Salopian), or Third Fauna: Lower or Llandovery, &c. C¹	Middle or Wenlock C²	Upper Division or Ludlow C³	Horizons
Hymenocaris vermicauda, Salter			*							Lingula Flags and Tremadoc.
,, *lata*, Salter			*							Tremadoc Upper Zones.
Lingulocaris lingulæcomes, Salter			*		*					Upper Tremadoc. Upper Llandeilo.
,, *siliquiformis*, Jones			*			*				Tremadoc Beds. Bala Rocks.
,, *Salteriana*, T. R. Jones and H. Woodward			*					*?		Lingula Flags. Brathay Flags.
,, *sp.*				*						Schiste Ardoisier (Maine).
Saccocaris major, Salter			*							Lingula Flags and Tremadoc.
,, *minor*, T. R. J. and H. W.			*	*						Tremadoc Slates and Arenig.
Caryocaris Wrightii, Salter				*						Skiddaw Slates, Ballantrae, Bennane Head. Pont Seiont, Huy (Belgium).
,, *Marrii*, Hicks				*						Skiddaw Slate, Pont Seiont.
,, *Salteri* (M'Coy)					*					Redesdale (Victoria).

Aptychopsis prima, Barrande							*	*		Étage E, Bohemia.
" *Barrandeana*, T. R. J. and H. W.							*			Birkhill Shales.
" *anatina* (Salter)								*		Wenlock, Lake District.
" *lata*, T. R. J. and H. W.							*			Gala Group.
" *glabra*, H. Woodward							*			" "
" *Wilsoni*, H. Woodward								*		Riccarton Beds.
" *Lapworthi*, H. Woodward							*	*		Birkhill, Skelgill, Grieston.
" *ovata*, T. R. J. and H. W.							*	*		Gala Group.
" *Salteri*, H. Woodward								*		Pencarreg, South Wales.
" *subquadrata*, T. R. J. and H. W.								*		Tipperary.
" *angulata* (Baily)							*	*		Birkhill, Tipperary, Brathay.
" *oblata*, T. R. J. and H. W.							*	*		" Gala, Riccarton.
Peltocaris aptychoides, Salter							*			" Gala.
" *Marrii*, T. R. J. and H. W.							*			" Skelgill.
" *patula*, T. R. J. and H. W.							*			" "
" *Carruthersii*, T. R. J. and H. W.							*			" Tieveshilly.
" (?) *Harknessi*, Salter							*			"
Pinnocaris Lapworthi, R. Etheridge, jun.				*					*?	Balclatchie, Kendal.
Discinocaris Browniana, H. Woodward							*			Birkhill.
" *ovalis*, T. R. J. and H. W.							*			"
" *undulata*, T. R. J. and H. W.							*			"
" *gigas*, H. Woodward							*			" Skelgill.
" *Dusliana*, Novák							*	*		Stage E–e, 1 Bohemia.
Caudal Appendages				*			*	*		Hawick, Galashiels, Skelgill, Pont Seiont.

TABLE IV.—*Geological Order of the Species.*

	Local Formation	Species
Third Fauna (Silurian, or Salopian).		
(C^3) *Ludlow* . . .	Kendal Beds of the Lake District	Pinnocaris Lapworthi.
(C^2) *Wenlock* . . .	Riccarton Beds of South Scotland	Aptychopsis Wilsoni. „ oblata. „ Salteri.
	Wenlock Beds of South Wales	
	Wenlock Beds of Rebecca Hill, Lake District	„ anatina.
	Wenlock Beds, Brathay Flags of the Lake District	„ angulata (?). Lingulocaris Salteriana (?)
	Wenlock Beds of Tipperary	Aptychopsis angulata. „ subquadrata
(C^1) *Llandovery, &c.* .	Gala Group of South Scotland (Tarannon, &c.)	Aptychopsis lata. „ glabra. „ Lapworthi. „ ovata. „ oblata. Peltocaris aptychoides.
	Birkhill Shales, Moffat, &c. (including all Llandovery, and locally the Tarannon)	Aptychopsis Barrandea. „ „ var. brevior. „ Lapworthi. „ angulata. „ oblata. Peltocaris aptychoides. „ Marrii. „ patula. „ Carruthersii (and at Tiveshilly, &c., Ireland). Discinocaris Browniana. „ ovalis. „ undulata. „ gigas.
	Skelgill Beds (or Coniston mudstones), Llandovery	Aptychopsis anatina. „ Lapworthi. Peltocaris patula. Discinocaris Browniana. „ gigas.

TABLE IV.—*Geological Order of Species*—continued.

	Local Formation	Species
	Second Fauna (' Ordovician' of Lapworth, &c.).	
(B^3) *Bala or Caradoc* .	Bala Beds of Corwen	Lingulocaris siliquiformis.
(B^2) *Llandeilo* . .	Balclatchie Beds, Girvan	
	Probably highest Llandeilo Beds	Pinnocaris Lapworthi.
	Upper Llandeilo Beds (near Builth)	Lingulocaris lingulæcomes
	Llandeilo (?) Beds of Australia	Caryocaris Salteri.
(B^1) *Arenig* . . .	Upper Arenig Beds of Caernarvonshire (Pont Seiont)	Hymenocaris vermicauda. Saccocaris minor. Caryocaris Wrightii. " Marrii.
	Skiddaw Slates (mainly Arenig)	Caryocaris Wrightii.
	Bennane Head Shales of South Scotland	" "
	Arenig	" Marrii.
	First Fauna (' Cambrian' of Lyell).	
(A^3) *Olenidian*, or Upper Cambrian.	Upper Tremadoc Slates	Hymenocaris vermicauda. " lata. Lingulocaris lingulæcomes. Lingulocaris siliquiformis. Saccocaris major.
	Lower Tremadoc Slates	Lingulocaris Salteriana.
	Upper Lingula Flags	Hymenocaris vermicauda.
	Middle Lingula Flags	Hymenocaris vermicauda.
	Lower Lingula Flags	Hymenocaris vermicauda. Lingulocaris Salteriana. Saccocaris major. ? Saccocaris minor.

2§. *Latest Additions to our Knowledge of the Lower Palæozoic Phyllopoda (Phyllocarida).*

There has not been much to notice additional in the study of Palæozoic Phyllopoda since the last (Eleventh) Report in 1894.

1. Professor Dr. Gustav Lindström, palæontologist in the State Museum of Sweden, has discovered and courteously sent to us specimens of a new *Emmelozoe*, not far removed in shape and features from *E. elliptica* (M'Coy). Several very definite individuals, with delicate, thin, shining carapace-valves, light brown, and somewhat iridescent, occur

in a bluish-grey marly shale from Lau in Gothland, corresponding with the Wenlock Shale of England. They will be figured and described in the 'Geological Magazine' before long as *Emmelozoe Lindstroemi.*

2. In the 'Sitzungsberichte königl. Böhmisch Gesellsch. Wiss., Math.-nat. Cl.' for 1894, article xxxvi. (separate copy dated 1894), Professor Dr. Anton Fritsch, in a preliminary report on the Arthropoda and Mollusca of the Permian formation in Bohemia, enumerates five species of *Estheria*, partly noticed in our Tenth Report, 1893, namely, (1) *Estheria triangularis*, Fr. (=? *E. tenella* in his 'Fauna der Gaskohle,' vol. i., p. 31), with remains of the animal, from the Gas-coal of Nyřan; (2) *E. cyanea*, Fr., from the Black-coal of Kounová; (3) *E. palæoniscorum*, Fr., covering whole beds in the Brandschiefer (Carbonaceous Shale) of Kőštialov; some individuals show the large antennæ; (4) *E. calcarea*, Fr., related to *E. minuta*; rare, in the red Plattenkalk of the Braunau district; (5) *E. ultima*, Fr., in the uppermost part of the limestone with *Amblypterus Feistmanteli*, near Vitouchov, not far from Lomnitz. There are also *Candona elongata*, Goldenberg, from the red limestone of Křečowic, near Rowensko (Turnau); and *Carbonia Salteriana*, Jones and Kirkby, in the red limestone of Stradonic, near Peruc; and *Cythere*, sp., in the red limestone of Klobuk, near Schlan.

Erratic Blocks of England, Wales, and Ireland.—Twenty-second Report of the Committee, consisting of Professors E. HULL (*Chairman*), J. PRESTWICH, W. BOYD DAWKINS, T. MCK. HUGHES, T. G. BONNEY, Messrs. C. E. DE RANCE, P. F. KENDALL (*Secretary*), R. H. TIDDEMAN, J. W. WOODALL, *and* Prof. L. C. MIALL. (*Drawn up by the Secretary.*)

[Read at Oxford, 1894.]

THE investigations of the Committee during the past year have yielded results of more than ordinary interest, though the amount of information to be embodied in their report is less than has been available during the previous two or three years.

A hope was expressed in the twenty-first Report that, as the result of an appeal made to the Corresponding Societies, information would be forthcoming regarding the Erratic Blocks of districts from which hitherto no returns had been sent in. This expectation has been realised; and the Committee, for the first time in their history, are now enabled to justify the reference to Ireland in the terms of their appointment. In response to the circular issued by this Committee to the Corresponding Societies, the Belfast Naturalists' Field Club promptly organised a committee to investigate the Erratic Blocks of the north-east of Ireland; and the first report, drawn up by the Honorary Secretary, Miss Sydney M. Thompson, and printed in the Proceedings of the Club (1893-94), is a valuable record of minute painstaking and accurate investigation. The Committee have not limited their work to merely recording the erratics, but have made a complete study of the Drift deposits, and their organic and other contents, at several selected exposures, and have transmitted to this Committee a series of twenty photographs illustrating the features described. Lincolnshire is also added to the list of English counties coming within the sphere of the actual operations of the Committee, and it is matter for congratulation that two observers have undertaken the work of recording the erratics of that county Two very important pieces of work have been undertaken by the Yorkshire Boulder Committee, one in the western portion of the area coming within their purview, near Barnsley, and the other, by the aid of the East Riding Boulder Committee, organised under the secretaryship of Mr. J. W. Stather, F.G.S., by the Hull Geological Society, in the country round Hull. In the latter case an exhaustive survey has been undertaken of *all* the erratics at present visible in the area selected, the one-inch map being divided into squares, and each square allotted to a worker, who will record every erratic above ground. The value of such a survey, in the elucidation of the complex problems of glacial geology, can hardly be over-estimated.

The Barnsley reports refer to a series of erratics, some of which were observed many years ago, but only a few of which were recorded. Fortunately, a local worker, Mr. W. Hemingway, preserved the information left in his hands by Professor A. H. Green, and supplemented it largely by his own observations. Mr. T. Tate, Secretary of the Yorkshire Boulder Committee, and the present writer, went over much of the ground under Mr. Hemingway's guidance, and can thus corroborate his testimony on many important points ; though a very large proportion of the erratics, especially such as were of a hard nature, have disappeared under the hammer of the road-mender. (It would be well here to remark that a like fate is rapidly overtaking many of the most interesting and significant of the ice-borne boulders in the country, and to reiterate the oft-repeated appeal to local observers to take prompt measures to record—and, if possible, to preserve—the erratics which come under their notice.) The especial interest of the groups observed lies in the fact that they are quite detached from the main lines of transport, and are so placed that they conceivably may have come by either of three routes—viz. : (1) with the train of erratics, exclusively from the Lake District, which is traceable down Calderdale to within a few miles of Royston and Barnsley ; (2) with the dispersion of Brockram, Shap granite, and other Lake District rocks, with a few Scottish rocks, which can be traced down Teesdale and the Vale of York ; or (3) with the coast dispersion characterised by a similar series to that of the Vale of York, with some Scandinavian and other crystalline rocks superadded. The abundance of rocks from the *northern* part of the Lake District is conclusive against (1), while the occurrence of crystalline rocks, red and grey granites, gneissose granites, and felspar porphyries, certainly coming from neither English nor South Scottish sources, seems equally against (2), leaving the third the probable direction of origin. Mr. Tate recognised a Norwegian aspect of the non-British rocks.

Another important report is that by Mr. W. Andrews, giving details of the dispersion of boulders from six small bosses of syenite which crop out about Sapcote, near Leicester.

CHESHIRE.

Reported by Surgeon-Major W. R. DAMBRILL-DAVIES, *per Glacialists' Association.*

Macclesfield—

2 Lake District andesites.

Alderley—

1 Eskdale granite; 1 L. D. andesite.

Knutsford—

4 Eskdale granites; 2 L. D. andesites; 1 Buttermere granophyre; 1 Scottish granite.

Derbyshire.

Reported by Miss Elizabeth Dale, *per Glacialists' Association.*

Buxton—

Lake District andesite and ashes, Buttermere granophyre, Silurian grit, chert gannister, toadstone.

Durham.

Reported by Mr. P. F. Kendall.

Beda Hills—

Carboniferous limestone, Carboniferous sandstone, clay ironstone, Lake District andesites and ashes, red granite, and a rock something like the Armboth Dyke, but much decomposed. These occur in gravel forming the Beda Hills.

Kip Hill—

Carboniferous limestone, Carboniferous sandstone, many Lake District andesites, porphyrite. No granites were visible at this place.

Durham (City)—

Lake District andesites, and a red granite with much black mica (perhaps Scottish).

Lincolnshire.

Reported by Rev. W. Tuckwell.

Grimsby—

2 grey granites (1 gneissose); 2 coarse red syenite, with some black mica. These rocks are probably *non-British.* 2 dolerites, probably Whin Sill.

Reported by Mr. J. Lorder.

Louth—

1 dolerite; 2 sandstones (? Jurassic); 1 red granite (scratched); 1 red granite (rudely foliated); 1 ? granite; red sandstone; ? blue granite.

Northumberland.

Reported by Mr. P. F. Kendall.

Little Mill—

Dolerite (? Whin Sill); sandstone; Carboniferous limestone; red porphyrite; jasper; red sandstone. These occurred in Boulder Clay, resting upon a surface cross-striated from three directions, viz. N., N. 4° E., and N. 40° E.

Warwickshire.

Reported by Mr. W. Andrews.

Coventry and Neighbourhood—

15 examples of the syenite, which crops out in 6 small bosses near Sapcote, 2½ miles S.W. of Leicester; 1 Mount Sorrel syenite.

YORKSHIRE.[1]

Communicated by the Yorkshire Boulder Committee.

Reported by Mr. W. HEMINGWAY.

Barnsley—

Shap granite.
Gneissose granite.
Grey „
Coarse „
Rhyolite.
Quartz porphyry ? (? Armboth Dyke).
Ennerdale granophyre.
Felspar porphyry.
Porphyrite.
Andesite.
Andesitic ash and breccia.
Rhyolitic breccia.
Diabase.
Magma basalt.
Olivine „
Borrowdale plumbago.
Carboniferous limestone.
Magnesian „
Flints (from Yorkshire chalk).
Lias limestone, with *Gryphæa incurva*

Reported by Mr. T. TATE.

Royston—

Volcanic ash; felsites; chert; magnesian limestone; 2 quartz felsites, Threlkeld; diabase; basalt.

Reported by Mr. W. GREGSON.

Baldersby—

1 Shap granite.

Kirklington—

1 basalt.

Reported by Mr. J. W. S. STATHER, *Secretary of the Hull Geological Society.*

Sheet 72 of 1-inch Map—Beverley.

North Cave—

1 basalt.

Market Weighton—

Carboniferous sandstone with fossils.

Banacks—

Carboniferous sandstone with fossils.

Chalk Villa—

Garnetiferous; mica schist; granite; basalt.

Reported by Dr. F. F. WALTON.

Newbold Church—

1 red granite; hard limestone.

South Cave—

Limestone.

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[1] The detailed report of the Yorkshire Boulder Committee, drawn up by the secretary, Mr. T. Tate, F.G.S., is published in *The Naturalist* (No. 231, October, 1894, pp. 297-303).

Reported by Mr. T. THELWALL.

Skidby and Little Weighton—
Basalt.

Reported by Mr. W. N. CROFTS.

Cottingham—
4 basalts.

Reported by Mr. J. NICHOLSON.

Swine—
4 basalts; 1 Millistone Grit; 5 Carboniferous limestones.

Reported by Mr. H. ROBINSON.

Sutton-on-Hull—
5 basalts; Carboniferous limestone; Liassic limestone with *Gryphæa*; granite.

Reported by Mr. P. F. KENDALL.

Out Newton, near Withernsea—
Elæolite syenite (?); Laurvigite (augite syenite of Laurvig); rhomb-porphyry.

Erratic Blocks of England, Wales, and Ireland.—Twenty-third Report of the Committee, consisting of Professor E. HULL (*Chairman*), Professor J. PRESTWICH, Professor W. BOYD DAWKINS, Professor T. McK. HUGHES, Professor T. G. BONNEY, Mr. C. E. DE RANCE, Mr. P. F. KENDALL (*Secretary*), Mr. R. H. TIDDEMAN, Mr. J. W. WOODALL, *and* Professor L. C. MIALL. (*Drawn up by the Secretary.*)

THE Committee have again to report that the work of recording the ice-borne erratics of Great Britain and Ireland has made satisfactory progress, and that several districts, regarding which no information was previously obtainable, have been reported upon.

The Yorkshire Boulder Committee, acting in conjunction with the sub-committee appointed by the Hull Geological Society, have presented another valuable report. Further details are furnished relating to the remarkable series of erratics found in the Yorkshire Calder; but the most noteworthy contribution is a tabulated list of no less than 2,070 boulders, comprising *the whole* of those visible *in situ* in the cliffs or lying on the shore above 'half-tide,' along a length of fourteen miles of coast of Holderness from Withernsea to Hornsea—a truly admirable piece of observation.

Several records are given of the occurrence of Scandinavian erratics at inland stations in Holderness. Other reports received from the same source deal with sporadic boulders in other parts of Yorkshire.

The Rev. W. Tuckwell, of Great Grimsby, has added to the list of erratics noted in Lincolnshire, and is taking active measures to secure the co-operation in the work of the clergy of the district.

New ground has been broken in the county of Northumberland, with some observations upon the erratics of the upper part of the Tyne valley, near Haltwistle.

Mr. Dwerryhouse furnishes a valuable and exhaustive series of reports upon the boulders of a portion of the Cheshire Wirral and the previously unrecorded district around the Wrekin in Shropshire.

For the first time since the appointment of the Committee reports have been received from South Wales, where Mr. Storrie has done some excellent work in the neighbourhood of Cardiff.

From Ireland a second report has been received from the Belfast Naturalists' Field Club.

ENGLAND.

CHESHIRE.

Reported by Mr. J. LOMAS, A.R.C.S., *and* Captain A. R. DWERRYHOUSE, *per Glacialists' Association.*

Prenton Village, near Birkenhead—

5 L.D. andesites; 1 fine L.D. Ash; 3 Yewdale breccias; 1 Eskdale granite; 1 Buttermere granophyre; 1 Scottish granite; 1 Criffel granite; 2 grits of undetermined origin.

Roman Road, near Little Storeton—

1 L.D. andesite.

Road behind Little Storeton—

2 L.D. andesites; 1 basalt.

Railway Cutting between Barnton and Neston—

1 limestone; 1 diorite.

Reported by Captain DWERRYHOUSE, *per Glacialists' Association.*

Sutton Weaver—

3 L.D. andesites; 3 Eskdale granites.

Preston Brook—

4 L.D. andesites; 2 Eskdale granites; 1 Buttermere granophyre; 1 Silurian grit.

Preston-on-the-Hill—

3 L.D. andesites; 3 Eskdale granites; 1 grit (? Silurian).

Willaston and Burton, near Neston—

40 L.D. andesites; 10 L.D. ashes; 1 L.D. andesitic agglomerate; 6 Eskdale granites; 3 Buttermere granophyres; 3 diorites; 3 Galloway granites; 6 Criffel granites; 1 felsite (reddish); 1 grit with numerous quartz-veins; 5 grits; 11 Silurian grits; 2 basalts; 1 limestone.

LINCOLNSHIRE.

Reported by Rev. W. TUCKWELL.

Great Grimsby—

Boulders of Whin Sill are common from Grimsby to Brigg. Several Scandinavian rocks from the neighbourhood of Christiania were found at depths of 10 to 15 feet in the foundations of the new Union.

NORTHUMBERLAND.

Reported by Mr. G. SLATER.

Haltwistle and Lambley—

Boulders averaging a foot in diameter:—

	Haltwistle	*Lambley*
Limestone	**40** per cent.	**3** per cent.
Millstone grit	**12** ,,	**20** ,,
Sandstone	12 ,,	—
Whin	9 ,,	15 ,,
Silurian	10 ,,	20 ,,
Granite	15 ,,	2 ,,
Grindstone sill	**2** ,,	**30** ,,
Permian	— ,,	10 ,,

N.B.—*The percentages are not to be relied on as correctly indicating the proportions at each place, but serve to show the contrast between the two localities in regard to the figures printed in heavy type.*

SHROPSHIRE.

Reported by Captain A. R. DWERRYHOUSE, *per Glacialists' Association.*

Wrockwardine—

12 Arenig felsites; 2 L.D. andesites; 1 Eskdale granite.

Between Wrockwardine and Walcot Station—

1 Arenig felsite.

Between Wrockwardine and Leaton—

1 Arenig felsite.

Leaton—

1 Arenig felsite.

Overley Hill [1]—

1 Eskdale granite; 2 Galloway granites; 1 Buttermere granophyre; 1 Triassic sandstone (local).

Wellington [1]—

2 Eskdale granites; 1 L.D. andesite; 1 Arenig felsite.

The Wrekin—

In Forest Glen:—1 Eskdale granite; 1 Criffel granite; 2 Silurian grits.
Wenlock Wood:—1 Eskdale granite; 1 Arenig felsite.
Near Newhouse Farm:—1 Arenig felsite.

Steeraway—

1 Eskdale granite.

Little Wenlock—

3 Eskdale granites; 1 L.D. andesite; 1 Galloway granite; 1 Arenig felsite.

Huntington—

4 Eskdale granites; 1 Galloway granite; 1 Criffel granite; 1 Silurian grit; 3 Arenig felsites; 1 Coal Measures sandstone (? local); 1 spherulitic rhyolite (Overley Hill); 1 basalt (? local).

Road Huntington to the Hatch—

2 Eskdale granites; 1 Arenig felsite.

Near Sapling Farm—

2 Arenig felsites.

Buildwas—

1 Eskdale granite; 1 Arenig felsite.

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[1] Observed by Mr. Lomas and Capt. Dwerryhouse.

YORKSHIRE.[1]

Communicated by the Yorkshire Boulder Committee.

Reported by Mr. J. BURTON.

Millwood, Tormorden—

Buttermere granophyre; granites (L.D.); grits (Millstone Grit).
The boulders here are much larger than those lower down the Calder Valley.

Mirfield—

Eskdale granites; L.D. andesites; Mountain Limestone with *Productus*.

Horbury—

Granites occur in a ridge of clay.

Reported by Mr. ROBERT LAW.

Millwood—

1 grey quartz-felsite; 6 Buttermere granophyres; 5 Eskdale granites; 2 L.D. andesites; 1 eurite; 1 mica trap.

Reported by Mr. THOMAS SALTONSTALL.

Luddenden Foot—

1 pink rhyolite; 1 Eskdale granite.

Sowerby—

1 pink rhyolite; 1 rhyolite; 2 Eskdale granites; 1 Buttermere granophyre; 1 L.D. andesite; 1 quartz-felsite; 1 porphyrite; 1 quartzite.

Reported by Mr. W. GREGSON.

Rokeby Park—

1 Shap granite.

Reported by Mr. T. CARTER MITCHELL.

Baldersby—

3 Carboniferous limestones.

Reported by Mr. E. HAWKESWORTH.

Saltburn—

3 Shap granites; 1 basalt.

Reported by Mr. T. SHEPPARD.

Burstwick—

Chalk and flint; lias limestone and marlstone with *Ammonites communis* and *Gryphæa incurva*; rhyolites; Carboniferous limestone; Brockram; Armboth quartz-felsite; Whin Sill; Rhomb-porphyry; red granite (? Scandinavian); gneiss.

Reported by Mr. J. W. STATHER.

Melton—

Laurvigite (augite-syenite of Laurvig); Rhomb-porphyry; Armboth dyke quartz-felsite; Brockram (Vale of Eden).

Bessingby—

Rhomb-porphyry.

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[1] This report will be published *in extenso* in *The Naturalist.*

Reported by the Hull Geological Society.

TABLE I.—*Boulders noted on the Holderness Coast between Withernsea and Hornsea,* 1895.

Boulders over 1 foot in diameter	A	B	C	D	E	F	G	H	I	J
	Withernsea to Sand-le-Mere. T. Sheppard and J. W. Stather, Aug. 17, 1895	Sand-le-Mere to Tunstall. T. Sheppard and J. W. Stather, Aug. 1895	Tunstall to Hilstone. W. H. Crofts and T. Sheppard, Aug. 1895	Hilstone to Thorp Garth. J. W. Stather, Aug. 1895	Thorp Garth to Aldborough. J. W. Stather, Aug. 1895	Aldborough to 1 mile N. Members Hull Society, April 1895	1 mile N. of Aldborough to Mappleton. Hull Society, April 1895	Mappleton to Hornsea. Hull Society, April 1895	—	—
Origin	3 Miles	1 Mile	1½ Mile	3½ Miles	½ Mile	1 Mile	2 Miles	2½ Miles	Totals	Per cent.
Carboniferous limestone	38	103	24	25	57	197	36	54	534	25·8
Sandstones, grits, &c., chiefly Carboniferous	12	49	19	13	17	85	33	47	275	13·3
Mesozoic Rocks: Lias shale	4	38	37	19	58	121	34	34	345	} 30·8
Mesozoic Rocks: Chalk	3	8	8	3	11	80	46	28	187	
Mesozoic Rocks: Other limestones and sandstones	2	5	21	5	14	26	12	19	104	
Basalts and other eruptive rocks	16	64	31	25	74	285	23	36	554	26·9
Granite, schist, gneiss, &c.	7	7	4	5	9	30	2	7	71	3·4
Totals	82	274	144	95	240	824	186	225	2070	100·0

TABLE II.

Boulders over 1 foot in diameter	A	B	C	D	E	F	G	H
	Withernsea to Sand-le-Mere	Sand-le-Mere to Tunstall	Tunstall to Hilstone	Hilstone to Thorp Garth	Thorp Garth to Aldborough	Aldborough to 1 Mile N.	1 Mile N. of Aldborough to Mappleton	Mappleton to Hornsea
	3 Miles	1 Mile	1½ Mile	3½ Miles	½ Mile	1 Mile	2 Miles	2½ Miles
Origin	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Carboniferous limestone, including possibly a few other Palæozoic sedimentary rocks	46·4	37·6	16·7	26·3	23·8	23·9	19·4	24
Sandstones, grits, &c., probably all from Carboniferous or other Palæozoic rocks	14·6	17·9	13·2	13·7	7·1	10·3	17·7	20·9
Mesozoic rocks, Jurassic limestones and sandstones, chalk, &c.	11	18·6	45·8	28·4	34·6	27·6	49·4	36
Basaltic and other eruptive rocks	19·5	23·4	21·5	26·4	30·8	34·6	12·4	16
Granite, schist, gneiss, &c.	8·5	2·5	2·8	5·2	3·7	3·6	1·1	3·1
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

I. The above is a rough classification of 2,070 boulders (above a foot in diameter) noted on the Holderness coast between Withernsea and Hornsea, a distance of 14 miles, during the summer of 1895.

II. All the boulders tabulated in sections A, B, C, D, E, G, H in the above table were *in situ* in the clay, or were close to the boulder clay cliff from which they were recently fallen. In section F, however, a large group of boulders occurred at about 'half-tide,' and these are included in the table.

III. Table I. gives the actual number of boulders noted in the different sections of coast.

Table II. gives the percentage of the different classes of the rocks.

IV. The largest boulder seen was a block of Carboniferous limestone on the beach near Mappleton (85 inches × 31 inches × 30 inches +). Many others approach this size.

A block of garnetiferous schist was noted at base of cliff near Cowden, 22 inches × 30 inches × 13 inches.

SOUTH WALES.

Glamorganshire.

Communicated by the Cardiff Society of Naturalists.

Reported by Mr. J. Storrie.

Pencoed, Bridgend—

Fragments of indeterminable marine shells; chert from Lias and Carboniferous limestone; no chalk flints; 4 or 5 Lower Lias limestone with *Gryphæa incurva;* 3 white cherty sandstone from U. Trias of St. Mary Hill; 7 or 8 Rhætic sandstones, with fossils from St. Mary Hill; 2 or 3 dolomitic breccia; Pennant Grit; Cockshot rock; over 100 Millstone Grit; 40 to 50 Carboniferous limestone; 35 Old Red sandstone, besides pebbles; 1 black micaceous flag (probably Llandeilo); 7 grits and yellow sandstones (probably Silurian); 1 fossiliferous Wenlock limestone; 2 granites (specimens mislaid); 3 'trap'; 1 brecciated 'trap'; 3 basalts; 1 porphyritic diabase (amygdaloidal); 1 volcanic ash; 1 rhyolite, showing macroscopic flow structure; 1 gabbro; 1 green rock with white chalcedony.

Some of these have been sectioned and submitted to petrologists, who note the following facts:—

One was identified with the gabbro of St. David's Head; a felsite bore some resemblance to the pre-Cambrian rocks of Pembrokeshire; 2 or 3 acid rocks, brecciated felsites, and tuffs were very like Carnarvonshire rocks, especially those of the Lleyn promontory. None was recognised as belonging to the volcanic rocks of the neighbourhood of Fishguard, of Mid Wales, or of any place further north than Carnarvonshire.

From these data it is concluded that the movement of transport was from the west or north-west.

Some were of such a general character that it was impossible to locate them.

IRELAND.

Co. Down.

Communicated by the Belfast Naturalists' Field Club.

Coast road between Ballymartin and Annalong—

1 Granite from Slievh Lawagan, Mourne Mountains.

Holywood—

Olivine gabbro, possibly from Slemish. The boulder was embedded in clay containing fragments of flint, chalk, basalt, and quartzite.

Island Hill, Strangford Lough—

2 Ordovician grits.

Rough Island, Strangford Lough—

Boulder showing junction of granite and Ordovician grit with vein of eurite; Ailsa Craig eurite; Antrim chalk and flint; pitchstone.

Co. ANTRIM.

St. Nicholas, Carrickfergus—

Large boulder of unidentified rock in fossiliferous Boulder Clay, containing a fragment of eurite from Tornamoney (coast of Antrim)

St. John's Whitehouse, on shore opposite Macedon—

1 fresh olivine dolerite, derived from one of the volcanic necks of Antrim.

Co. CAVAN.

Blacklion—

1 Millstone Grit.

The stone is perched on a pedestal of Carboniferous limestone. Its upper surface is sculptured with concentric circles like those on cover-slabs of Kist-vaens.

Some Suffolk Well-sections.

By W. WHITAKER, *B.A.*, *F.R.S.*, *F.G.S.*, *Assoc.Inst.C.E.*

[Ordered by the General Committee to be printed in full.]

Accounts of seventeen wells having come to hand since the last Geological Survey Memoir that deals with Suffolk was issued, advantage is taken of the meeting of the British Association at Ipswich to make them public.

A great number of well-sections in the county have been printed in the following Geological Survey Memoirs, to which inquirers are referred :—

1878. The Geology of the N.W. Part of Essex . . . with Parts of . . . Suffolk, p. 84.

1881. The Geology of the Neighbourhood of Stowmarket, pp. 18–25.

1881 (or 2). The Geology of the Country around Norwich, pp. 156 (and diagram), 157, 158, 162, 166.

1884. The Geology of the Country around Diss, Eye, Botesdale, and Ixworth, pp. 29–41.

1885. The Geology of the Country around Ipswich, Hadleigh, and Felixstow, pp. 111–125.

1886. The Geology of the Country around Aldborough, Framlingham, Orford, and Woodbridge, pp. 50–57.

1886. The Geology of the Country between and south of Bury St. Edmunds and Newmarket, pp. 20–25.

1887. The Geology of Southwold, and of the Suffolk Coast from Dunwich to Covehithe, pp. 78–80.

[Words in square brackets have been added by the writer.]

1887. The Geology of the Country around Halesworth and Harleston, pp. 36–39.

1890. The Geology of the Country near Yarmouth and Lowestoft, p. 83.

1890. The Pliocene Deposits of Britain, p. 110.

1891. The Geology of Parts of Cambridgeshire and of Suffolk, pp. 114–119.

1893. The Geology of South-western Norfolk and of Northern Cambridgeshire, pp. 161–164.

CLARE. *Snow Hill (half a mile N. of the Church), by the roadside*, 1894.

About 176½ feet above Ordnance Datum.

Made and communicated by Mr. G. INGOLD.

Water rose to 15½ feet from the surface.

			Thickness in Feet	Depth in Feet
[Glacial Drift]	Boulder clay	White clay	7	7
		Brown clay	6½	13½
	Red and green sand		11½	25
Chalk, very rotten, and with very few flints	Soft brown chalk		35	60
	Soft white chalk		42	102
	Harder white chalk		38	140

HAVERHILL. *Waterworks, Camps Road*, 1894.

Nearly 297 feet above Ordnance Datum.

Made and communicated by Mr. G. INGOLD.

Shaft, 103 feet ; the rest bored. Water-level, 73¾ feet down. Yield exceeding 150 gallons a minute.

		Thickness in Feet	Depth in Feet
Mould		3	3
[Drift]	Brown sandy loam	2½	5½
	White boulder clay	11½	17
	Blue clay	6	23
	Blue and brown clay	2	25
	Chalk and clay	3	28
Upper Chalk, with flints (especially from 130 to 230 feet down)		227	255

HITCHAM.

Communicated by the Rev. E. HILL, from information from Mr. COBBOLD, well-sinker.

The Hall. About 175 feet above Ordnance Datum. Well 60 feet deep.

[Drift] { Blue clay.
Brighter clay and marl.
Sand and consolidated flint-pebble-bed, from which the water comes.

The Rectory. About 235 feet above Ordnance Datum. Well 102 or 103 feet deep. At 100 feet a 'fault' (so-called) of hard sand, from which the water comes. [Drift.]

Squirrel's Farm. Eastern end of parish. Well said to be 100 feet deep, all in [Boulder] clay.

KETTLEBASTON. *High House Farm. About* 230 *feet above Ordnance Datum.*

Communicated by the Rev. E. HILL.

Well 70 feet to water.

MARKET WESTON. *Small Farmhouse on the Bury Road, near Hopton Greyhound,* 1889.

Made and communicated by Messrs. GEDNEY (of Norwich).

Shaft 35 feet, the rest driven tube.

		Thickness in Feet.	Depth in Feet
Made Soil		1	1
[Drift]	Red sand	15	16
	Grey sand	14	30
	Quick sand	5	35
	Gravel	12	47
	Sharp red sand	16	63
	Grey sand	38	101

MELTON. *Suffolk County Asylum (at a distance from the Asylum).*

From a Report by Mr. G. HODSON, 1894.

Test boring, No. 1, 1891.

Yield proved to 348,000 gallons a day. Water very hard.

		Thickness in Feet	Depth in Feet
Soil		3	3
Drift and Crag ?]	Sand and gravel	$4\frac{2}{3}$	$7\frac{2}{3}$
	Sand	$10\frac{1}{3}$	18
[Reading Beds, 34 feet]	Coloured [mottled] clay and drift-flints	2	20
	Mottled clay { Red	2	22
	Mottled clay { Light blue	$\frac{1}{2}$	$22\frac{1}{2}$
	Brown sandy clay	$8\frac{1}{2}$	31
	Green sandy clay	1	32
	Brown running sand	12	44
	Blue clay	6	50
	Green sand and flints	2	52
[Upper Chalk] Flints and chalk		248	300

Test boring, No. 2, 1891 (?).

Yield insufficient at the depth of 300 feet. Continued for another 50, in which a further supply was found. Yield proved to be 240,000 gallons in 24 hours, the water being lowered 14 feet.

		Thickness in Feet	Depth in Feet
Soil		3	3
[Drift ?] Sand and gravel		14	17
[Reading Beds, 35 feet]	Coloured [mottled] clay	5	22
	Sand and clay	2	24
	Brown clay	8	32
	Running sand	12	44
	Sand and clay	3	47
	Dark clay	4	51
	Green sand	1	52
[Upper Chalk] Flints and chalk		298	350

NAUGHTON. *Rectory. About 282 feet above Ordnance Datum.*

Communicated by the Rev. E. HILL, from information from Mr. COBBOLD, well-sinker.

Well in blue [Boulder] clay to the depth of 130 or 140 feet.

STANNINGFIELD. *Half a mile N. 15° E. of the church, at the spot marked 'Well' on the 6-in. map (in error, as there was only a pit there).* 1894.

Communicated by the Rev. E. HILL, from information from the owner, Mr. CROSSFIELD, verified by inspection.

310 feet above Ordnance Datum.

Sunk to the depth of 111 feet, when water rose to 56 feet from the surface.

Wholly through grey chalky Boulder Clay, with chalk pebbles (some scratched), large flints, fragments of Kimeridge Clay and of *Ammonites.* The flints and Kimeridge Clay occurred noticeably at the depth of 60 to 80 feet.

STRADISHALL. *Public Well.* 1893.

Made and communicated by Mr. G. INGOLD.

Shaft. Water-level $35\frac{3}{4}$ feet down.

		Thickness in Feet	Depth in Feet
Mould		2	2
Loamy sand		2	4
[Boulder Drift]	White clay	5	9
	Brown clay	4	13
	Blue clay	47	60
Chalk		9	69

STUTTON. *The Hall. About $1\frac{1}{3}$ miles S. of W. from the Church.*

Communicated by Mr. G. F. MANSELL.

		Thickness in Feet	Depth in Feet
Soil		3	3
Gravel		10	13
[London Clay, 71 feet]	Coloured clay	4	17
	Blue clay	12	29
	Sandy clay	55	84
[Reading Beds, 53 feet]	Mottled clay, with claystone (3 inches) 2 feet down	$12\frac{1}{4}$	$96\frac{1}{4}$
	Stone	1	$97\frac{1}{4}$
	Green clay and sand	$24\frac{3}{4}$	122
	Dark clay	7	129
	Clay and a little sand	$7\frac{1}{4}$	$136\frac{1}{4}$
	Flint and pebbles	$\frac{3}{4}$	137
Chalk and flint		6	200

THORPE MORIEUX. *Chinery's Farm*, 270 *feet above Ordnance Datum.*

Communicated by the Rev. E. HILL, from information from Mr. COBBOLD, well-sinker.

Well 120 feet deep. 'Mostly blue clay ; sandy gall at bottom.'

TRIMLEY. *Felixstow and Walton Waterworks.* 1893.

Communicated by Mr. H. MILLER.

Sixty feet above Ordnance Datum. Iron cylinders 83 feet, the rest bored. Water rose to 55 feet from the surface. Supply good. Quality excellent.

		Thickness in Feet	Depth in Feet
Soil and Crag		8	8
[London Clay]. Clay and loam, with 7 inches of septaria $88\frac{1}{2}$ feet down		81	89
[Reading Beds, 36 feet]	Mottled clay	18	107
	Dark clay	9	116
	Greenish sand	9	125
Chalk. Thin layers of flints 144, 161, 165, and 178 feet down		$116\frac{1}{2}$	$241\frac{1}{2}$

WATTISHAM. *Opposite the gate to the Hall.*

Communicated by the Rev. E. HILL, from information from Mr. COBBOLD, well-sinker.

Road-level about 285 feet above Ordnance Datum. Well 80 feet deep, mostly through stiff blue [Boulder] clay.

WOODBRIDGE. *The Thoroughfare. Mr. Carter's.* 1895.

Made and communicated by Mr. F. BENNETT.

Good supply. Water stands about 26 feet down.

		Thickness in Feet	Depth in Feet
Well (? old), the rest bored		—	28
[? Crag or Eocene] Running sand		12	40
[Reading Beds, 26 feet]	Mottled clay	10	50
	Green sand	9	59
	Running sand	$2\frac{1}{2}$	$61\frac{1}{2}$
	Dark green sand and flints	1	$62\frac{1}{2}$
	Mottled clay	2	$64\frac{1}{2}$
	Dark green clay	$1\frac{1}{2}$	66
[Upper Chalk]	Chalk, with flints nearly every foot	64	130
	Mottled clay [? a marl-bed in the chalk, or pipe of Reading Beds?]	$\frac{1}{2}$	$130\frac{1}{2}$

On the Dip of the Underground Palæozoic Rocks at Ware and Cheshunt.

By JOSEPH FRANCIS, *M. Inst., C.E.*

[Ordered by the General Committee to be printed *in extenso*.]

IT has come to my knowledge that some of the geologists specially interested in ascertaining the lie of the ancient rocks beneath the Eastern Counties of England, are doubtful whether any value is to be attached to statements that have been made with regard to the dip of these rocks at certain places. I refer especially to two instances in which borings were made into the strata underlying the Gault to the north of London, and where much time and money were spent in obtaining the true angles and directions of dip. It was in the year 1879 that these observations were made, but it does not appear that any description of the methods adopted has hitherto been published, and Mr. Whitaker has suggested that I should give a short account of the experiments that were carried out by me under the direction of the late Mr. James Muir, the former engineer to the New River Company. This I now propose to do, and hope to be able to show that the recorded results may be accepted as perfectly reliable.

These borings were undertaken by the New River Company on the advice of geologists who were of opinion that the Lower Green Sand extended to the outskirts of London, and that when found, it could be relied upon to afford a plentiful supply of pure water for the use of the metropolis. The outcrop of the Lower Green Sand to the north of London extends from Leighton Buzzard to Ely, over an area of 166 square miles, and consequently must receive on its surface an immense quantity of rain water; moreover, being extremely pervious, it must be capable of transmitting through its mass a large percentage of the rainfall. Nearly forty years before this, a good yield had been obtained from the same formation, at a depth of 1,800 feet, at Grenelle, near Paris, and later on at Passy, in the same neighbourhood. A deep bore at Kentish Town, made in the year 1855, had revealed the fact that a ridge, if nothing more, of ancient rocks protruded upwards to the Gault, and this discovery raised considerable doubt as to the extent of the sandy layer under ground. There was also a great amount of uncertainty as to whether this stratum, which is so prolific of water when tapped anywhere near its outcrop, would yield equally well where compressed by the weight of a thousand feet or more of superincumbent earth. On the other hand, the Royal Commission on Water Supply, which sat in 1869, had reported that 'so far as this Green Sand continued, it would form a valuable and copious water-bearing bed,' and it was felt that the problem was one of such extreme importance that it was of the utmost consequence it should be solved. The water supply, which there was a chance of so gaining, was so convenient and good as to justify some amount of speculation in endeavouring to obtain it, whilst there was, in any case, a certainty of a large accession of Chalk water from the upper part of the bore. I may here remark that, although several eminent men decidedly encouraged the venture, they can hardly be held responsible for the extravagant notions entertained by some persons, who assumed that this experiment was about to solve the whole question of the future supply of water to London.

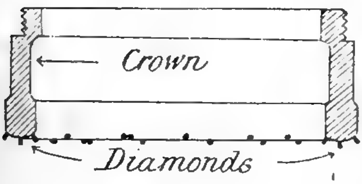
One of the borings to which I wish to call attention was made at Ware, and the other at Turnford, near Cheshunt, both in the county of Hertford. These particular places were chosen because they offered suitable sites for new Chalk wells, and because land alongside the channel of the New River was available for pumping stations. On reaching certain depths, the bore holes furnished conclusive evidence that it was quite hopeless to expect a supply of water from below the Gault, and orders were about to be given for a cessation of the work, when those geologists who had watched the progress of the enterprise, expressed a wish that endeavours might be made to learn the direction of the dip of the lowest stratum reached in each case. Instructions were thereupon given for the requisite investigation to be made, and when the inquiry was found to involve additional boring, the construction of special apparatus, and the devotion of much time and attention, these were liberally provided by the New River Company. A number of men of science formed themselves into a Committee to advise as to the best way of obtaining the desired information. This Committee consisted of Sir William Thomson, now Lord Kelvin, Dr. C. W. Siemens, Mr. Etheridge, Professors T. McK. Hughes, Maxwell, and Stokes, Mr. Mylne, and Mr. Muir.

From time to time they discussed various modes of proceeding, and under their advice the several experiments were arranged. In carrying out their suggestions, every possible care was exercised to ensure correct results, and observations were repeated until there could be no reasonable doubt of the truth of the conclusions arrived at.

Before describing in detail the appliances used, I may give a general outline of the circumstances preceding the discovery of Silurian Rock at the Ware boring, and of Devonian at Turnford.

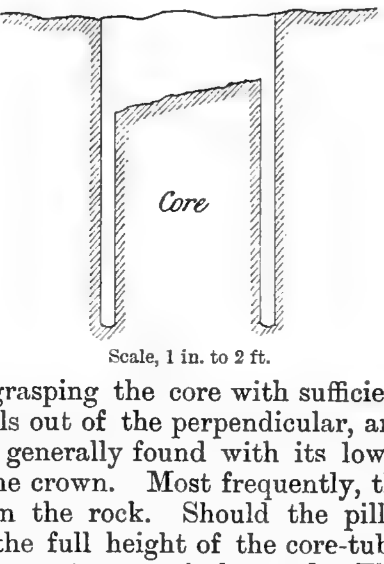
Before the year 1872, a well had been sunk into the Chalk at Turnford, and pumping engines erected. The shaft had a depth of 176 feet, with a bore hole 34 inches in diameter, extending to a depth of 362 feet from the surface of the ground. The bore was made of this large size in order to admit of its being continued downwards to a great depth without undue contraction of diameter, in case it should be afterwards decided to search for the Lower Green Sand; but it was not until 1874 that it was resolved to follow up the question. Arrangements were then made for deepening the bore and for dealing with any water that might be obtained from the hoped-for deep source. To convey the expected supply of water to the surface, a wrought iron tube of 24 inches internal diameter, and long enough to reach to the bottom of the hole, was provided. Its joints were made quite watertight throughout by calking, and all access of water from a higher level was to be shut off by sealing up an annular space to be left around the tube where it passed through the Gault clay. The sinking of this tube to a depth of 896 feet, was accomplished by the old system of breaking up the material with chisels and bringing it to the surface by means of buckets with valves in the bottom. In the meantime, the more rapid method of rock-boring by means of diamonds had become a success, and, after due consideration, it was decided to put down a hole by this means at another spot in order to obtain an early solution of the question. A site near Ware, six miles north of Turnford, was selected, and in the beginning of the year 1878 a boring by the new process was commenced there. By this method, a number of black diamonds fixed in one end of a ring or short tube of steel, technically called a 'crown' (fig. 1), are caused to rotate against the rock to be drilled, and the diamonds, being harder than any other known substance, cut their way through, forming an annular groove which becomes deeper and deeper as the crown is slowly lowered. A cylindrical core of undetached rock is thus left standing in the middle (fig. 2), and is received in a long tube of a somewhat greater internal diameter than the crown which it surmounts. To the closed top of this core-tube is attached a column of tubular rods, by which a rapid rotary motion is transmitted from machinery above, and down which water is pumped, with the double purpose of keeping the drill cool and of bringing up the abraded material. To admit of the passage of the water from the inside to the outside of the crown, grooves are formed across the cutting face, and through these the water is forced, carrying with it the *débris* cut away by the diamonds. The water then passes upward outside the core-tube to the top of the hole, bringing with it the lighter of the particles. Above the core-tube, and enclosing the lower end of the suspending rods (fig. 3), there is an open topped tube of a few feet in length, into which the heavier matter falls, and this sediment tube is emptied when the crown is raised to the surface. Before the core can be brought up from the bottom it must be detached from its bed. This is usually effected by friction during the revolution of

FIG. 1.



Scale, 1 in. to 1 ft.

FIG. 2.



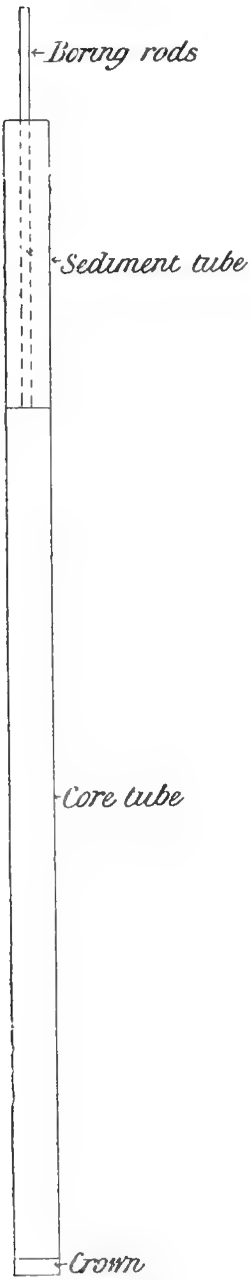
Scale, 1 in. to 2 ft.

the crown in boring, the inner surface grasping the core with sufficient force to break it off. The block then falls out of the perpendicular, and when the boring-rods are drawn up, it is generally found with its lower end resting on the internal shoulder of the crown. Most frequently, the fracture occurs at a bed or other joint in the rock. Should the pillar remain firmly fixed after it has attained the full height of the core-tube, one of the various appliances known as core-extractors is lowered. This firmly clips the core at the bottom, and on the application of adequate lifting power to the rods, the piece is broken off and can be withdrawn. In this way, solid columns, 30 feet in length, and 16 inches in diameter, were obtained.

The great advantage of the system is, that substantial specimens of the materials bored through can be obtained, and their relative positions actually seen. No room is left for doubt as to the depths and thicknesses of the various strata, and since the hole is put down perfectly vertical, there is no difficulty in ascertaining the exact angle of the dip if it is steep enough to be appreciable in the core. On the other hand, the rotation of the apparatus precludes all knowledge of the direction of dip by mere inspection, and special means have to be devised for ascertaining this particular.

Returning now to my narrative of events. When it was decided, in 1878, to put down a test hole at Ware, it was anticipated that the Gault there would have been passed through before the Turnford boring had progressed very much beyond its then depth of 836 feet, in which case the latter could have been discontinued if the Ware site proved unfavourable; for it was obvious that if the Lower Green Sand did not yield water at the more northerly of the two points, it would not do so at the other, which was so much farther from the outcrop. But delays occurred. Soon after starting, the boring-rods broke in consequence of a fall of gravel from above; the core-tube and a core-extractor were dropped to the bottom, and the guide-pipe at the top was carried away. This necessitated the sinking of cast-iron cylinders, 6 feet in diameter, to a depth of 30 feet from the surface, by means of compressed air; a work that occupied some time. Later on, a rod became bent near the bottom of the hole at a depth of 780 feet, and much time was lost in recovering the crown and tubing which were set fast by this accident. Thus the work occupied much more time than had been expected, whilst at the Turnford boring, the contractors (Messrs. Docwra & Son), after reaching a depth of 896 feet, adopted the diamond drill, and in this way hastened the completion of their work. Whereas the boring by chisels had been proceeding through the Gault clay at an average rate of about 2 feet in depth per week, by the new process an advance of 18 feet or more was made in the same time. Thus it eventually happened that the Gault was pierced through at both places at about the same time.

FIG. 3.



Scale, 1 in. to 8 ft.

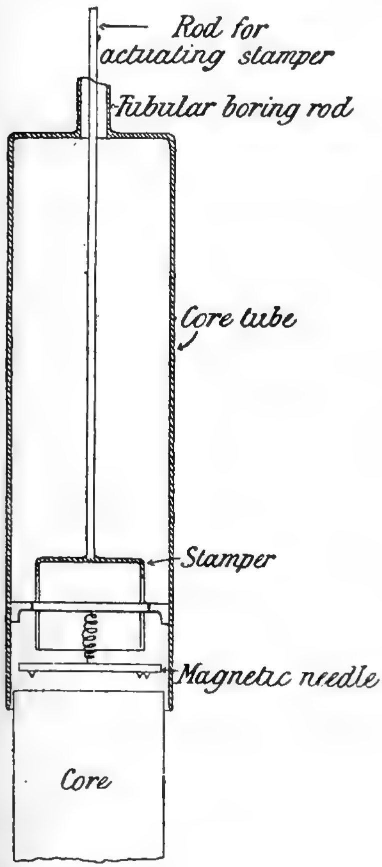
Shortly before this, a boring made at Crossness for the late Metropolitan Board of Works had shown that there was no Lower Green Sand in that locality; whilst at Tottenham Court Road, Messrs. Meux had bored through 64 feet of what was at the time erroneously supposed to be Lower Green Sand, and had found it to be a comparatively compact stone, containing but little water. These facts were discouraging, but they still left room for hope that the thinning-out of the water-bearing stratum was confined to the deepest part of the London basin. The results of the New River Company's borings were, therefore, looked for with great interest, and when, in May 1879, Silurian rock was struck at a depth of $796\frac{1}{2}$ feet at Ware, and, a month later, Devonian was found at a depth of $980\frac{1}{2}$ feet at Turnford, those who took a scientific interest in the question, naturally tried to secure all the information obtainable under these exceptionally favourable circumstances. Hence the demand for a special inquiry as to the direction of the dip of these rocks.

At neither place was there any Lower Green Sand, although in each case the occurrence of a dark-coloured sand, several inches in depth, above the Palæozoic Rocks gave rise to the belief that the stratum was represented in an attenuated form. Recent investigation by Mr. W. Whitaker and Mr. A. J. Jukes-Browne has, however, shown that this was merely the basement bed of the Gault, whilst the 64 feet of rock occurring between the Gault and the Old Red Sandstone at Messrs. Meux's well, has been declared by the same authorities to belong to the Jurassic system.

I will now proceed to describe the various appliances, either suggested or used, for obtaining the desired information, and the manner in which the experiments were conducted.

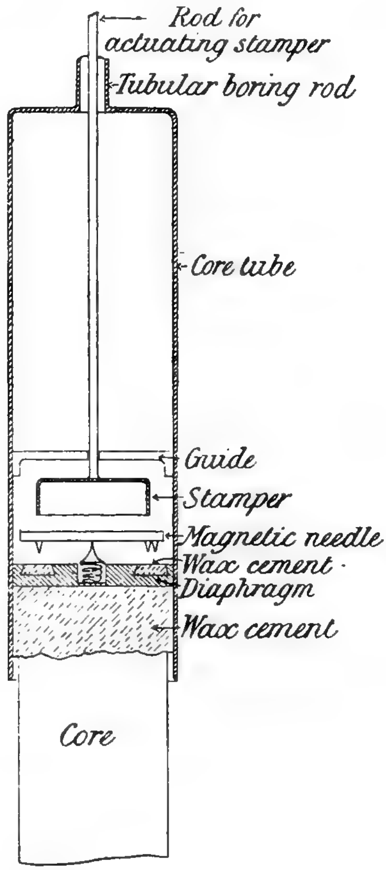
The first idea that occurred was, to make use of a magnetic needle.

FIG. 4.



Scale, 1 in. to 2 ft.

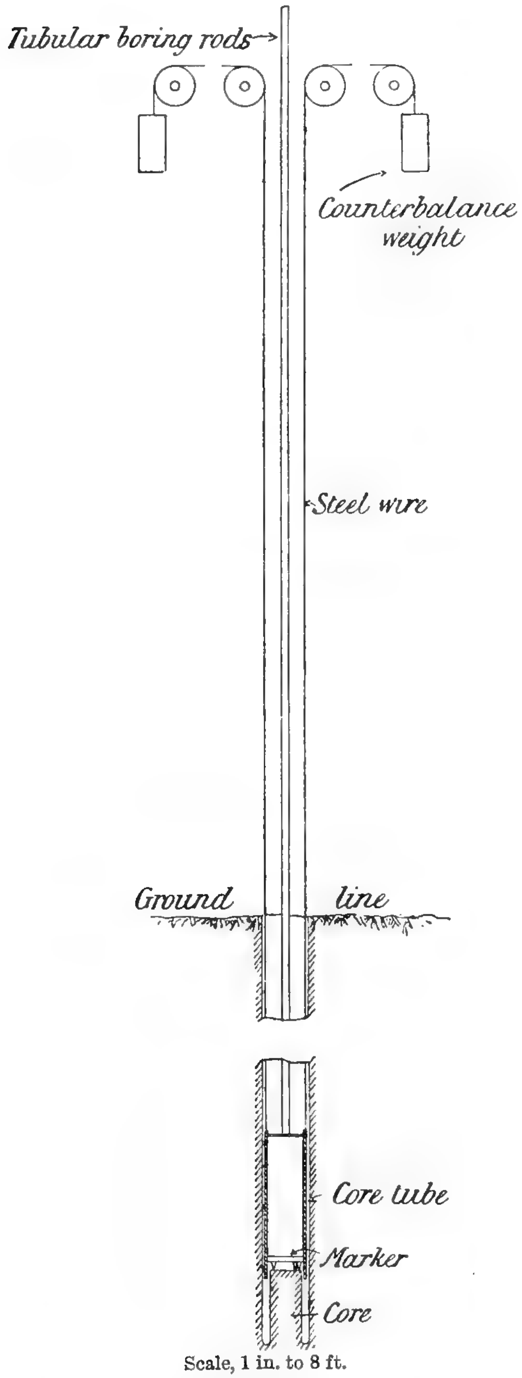
FIG. 5.



Scale, 1 in. to 2 ft.

Suitably mounted, this would be lowered on to the top of a piece of core that was still affixed to its base, and when it had come to rest in its natural position, it would either be secured immovably to the core, or its impress stamped in some way upon the top. If a sufficiently long piece of core were then broken off and brought up, the angle between the line of dip and the magnetic meridian of the day could be directly read off the specimen by means of a protractor. For fixing the needle in position when arrived at the bottom, various devices were suggested, including, amongst others, its enclosure in a pressure-tight box, so arranged as to be capable of becoming firmly attached to the core when lowered over it. In this box was to be a solution of gum mastic, from which the gum could be thrown down by the admixture of water that would be allowed to gain access by the opening of a stopper manipulated from above. The whole could afterwards be lifted without altering the relative positions of the parts. Another proposal was, first, to grind the top of the core to a level surface (fig. 4), and then to let down a strong needle supported on a spring centre, and having steel points affixed underneath, two near its north end and one near its south end. By releasing a weight, or putting on the steady downward pressure of a screw, the points were to be forced into the rock, giving the line of meridian in the most direct manner. A plan was also suggested for lowering a mass of plastic material (fig. 5), such as wax, on to the roughly fractured top of the fixed core, and after an impression had been taken, the frame carrying the wax was, before withdrawal, to be marked by a magnetic needle suspended above its upper surface. This was to be accomplished by having an annular groove, also filled in with wax, on the upper side of the carrier. The needle would be balanced on a spring point at the centre of this circle, and would have differently shaped points on its under side at either end just over the ring of wax. By pressing these down when they had finally come to rest, the direction would be given upon the carrier, ready for transference, first to the cast of the core, and afterwards to the core itself, when this was brought to the surface.

Fig. 6.

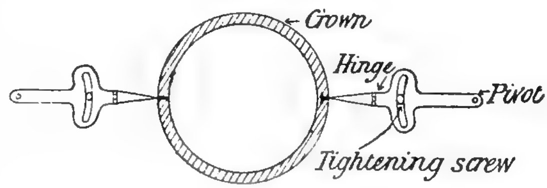


Scale, 1 in. to 8 ft.

But there were difficulties in arranging an instrument that would be likely to work satisfactorily on these lines. The risk of disturbing the needle during the descent of a weight or the inflow of a liquid was very great; but the principal objection was, that the tubes to which the apparatus must be connected were of steel, and would in all probability so disturb the movements of the magnet as to lead to erroneous conclusions. So also, masses of iron in the earth might cause deflection, whilst there would be nothing to indicate that such had occurred. The idea of attempting to trace the magnetic meridian on the rock was consequently abandoned, and it was next considered how the core, or a cast of it, could be marked with some other known line of direction. To do this, the carrier of the marking apparatus, or of the plastic material, must be placed over the centre of the hole, with a horizontal line, the bearing of which is known, marked upon it. It must then be lowered to the bottom and made to operate without receiving the slightest permanent twist during any part of the movement. This maintenance of a marked diameter always in the same azimuth was the most difficult requirement to fulfil. The earliest proposal was, to stretch a pair of fine steel wires vertically between a core tube (fig. 6), used as a marking frame, and the top of the boring stage, at 30 feet above ground. These wires were to be on opposite sides of the axis of the boring-rods and at equal distances therefrom, but no nearer to each other than was necessary for clearing the sides of the bore-pipe all the way up. They were to be made fast at their lower ends to the core tube, but at the top were to be passed over pulleys, and attached to heavy counterbalance weights for keeping the lines tightly strained during the descent of the marker. There would thus be about 30 feet in height of each always visible, and by placing a theodolite on one side, in the plane of the wires, one of them could be kept under observation, and any deviation from the vertical that might be caused by unavoidable rotation seen, whereupon the marker would be at once restored to its correct position by moving the rods round at top. But the length of wire exposed would have been so small, compared with the full depth of the hole, that it was feared a considerable amount of twist might occur at bottom without detection by the instrument. That plan was consequently given up, and means were contrived for observing the boring rods themselves, and guiding them in such a manner as to prevent all possibility of twist. The details of this arrangement I will now explain.

On the circumference of the crown or tube carrying the marker, the ends of a diameter were indicated by differently shaped notches. At the commencement of an experiment, the tube was suspended with these notches opposite to two sharp pointers (fig. 7), which were firmly fixed at the level of the ground line on opposite sides of the hole, and at such a distance from its axis as just to clear the crown. The pointers were hinged to fold back, so as to leave ample space for the core-tube to pass freely down.

Fig. 7.

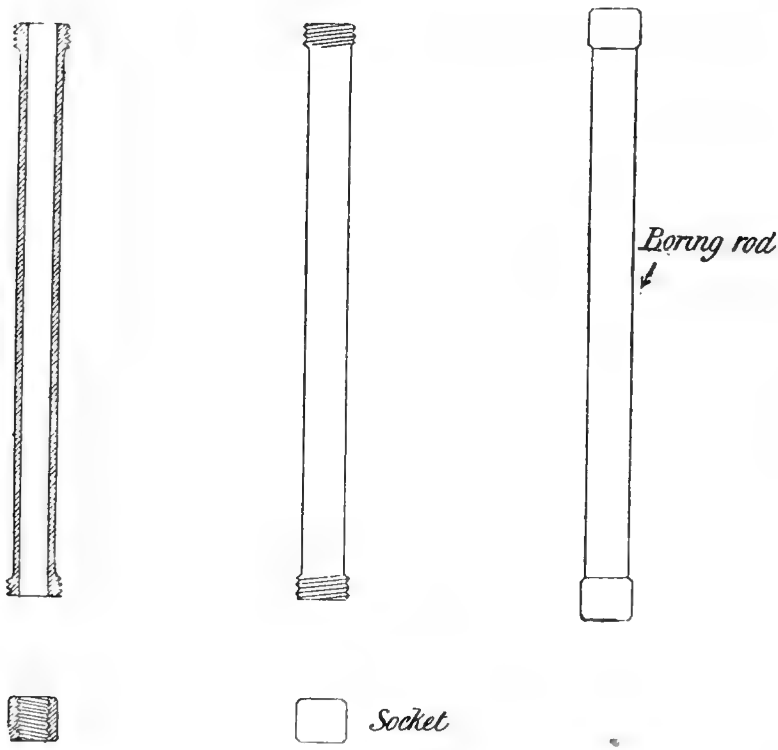


Scale, 1 in. to 2 ft.

I should mention that the boring-rods at Ware were made of steel and were tubular, $1\frac{7}{8}$ inches inside and $2\frac{1}{2}$ inches outside diameter, and 5 feet in length, with screwed ends (fig. 8). They were coupled up by internally screwed sockets, but when being lowered or raised they were connected or disconnected in 30 feet lengths. At about 6 feet from the axis of the hole, in a convenient direction, was hung a long fine plumb-line (fig. 9), towards which a horizontal radial arm, clamped on the boring-rods at 30 feet above the ground, was directed. On the outer end of the radial arm was an adjustable pointer, the sharp edge of which was set to almost touch the plumb-line. The rods were slowly lowered for 30 feet, with every endeavour to avoid rotation, but if the radial pointer *did* deviate at all from the plumb-line, this was corrected by gently twisting the rods. A second radial arm, exactly similar to the first, was then clamped on at 30 feet higher up, and its pointer accurately set to the line, after which the lower one was removed. This was repeated until the marking tool reached the core, and in returning to the surface the process of fixing and unfixing the radial arms was performed in reverse order.

The form of apparatus to be used for establishing a connection between

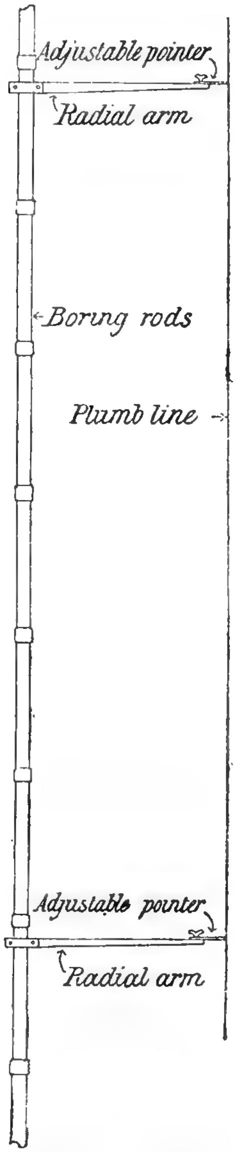
FIG. 8.



Scale, 1 in. to 2 ft.

the marked diameter on the crown or tube and the unbroken rock, next claimed attention. Whatever method might be adopted, it was obvious that it was only whilst the rock was *in situ* that this relation could be determined, and consequently the greatest care would be necessary to ensure that any core operated upon had not been broken off during the revolution of the boring crown. At Ware, the first trial was made in the following manner. Three steel V-shaped cutters (fig. 10) were fixed on the inside surface of a boring crown, at a distance of $1\frac{1}{2}$ inches from its lower end, and with their cutting edges at such a distance from the axis of the crown as was about $\frac{1}{8}$ of an inch less than the radius of the core, whose diameter was $13\frac{1}{4}$ inches. One of these cutters was set on the line of diameter indicated by the notches on the outside of the crown, and the other two cutters were placed at equal distances from the same line on the opposite side of the circle, thus marking distinctively the *one* end of the diameter from the *other*. Crown and cutters were carefully lowered into the bore hole and over the core at its bottom, with every precaution to maintain the aforesaid diameter in the same known direction. They were then brought up with the same care, and so successfully, that the crown returned to the surface with its marked diameter exactly in the direction in which it began to be lowered.

FIG. 9.

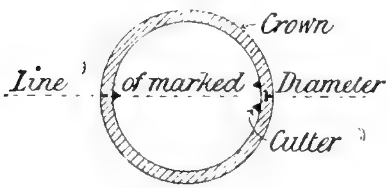


Scale, 1 in. to 8 ft.

As a check upon what had been done, a cast was then taken of the rough top of the stone. To do this, a tube of a size to encircle the core (fig. 11) was prepared by fixing a diaphragm in it at a distance of 9 inches above its lower end, and filling in beneath this diaphragm, to a depth of 6 inches, a mass of wax, softened with spirit of turpentine, and coloured with Venetian red. A diameter was marked, as in the preceding case, by notches at either end, and the whole was lowered upon the core with the same care to keep the marked diameter in the proper azimuth. Just before making the imprint, water was pumped through a pipe, $1\frac{1}{2}$ inches in diameter, that passed down the middle of both diaphragm and wax. There was thus removed from the top the sediment that would otherwise have prevented a true impression being obtained. The weight of the core-tube, rods, and boring head, was counterbalanced, so that a pressure of only 10 lbs. per square inch came upon the surface of the wax, but nevertheless, great difficulty was experienced in arriving at the proper consistency for the plastic material. If too soft, it would not retain its place until it reached the bottom, and if too hard, a satisfactory print could not be obtained. After several failures, the right admixture was hit upon, and a cast secured. The tube, with its mould of wax, was then brought up, without having received the slightest twist from the time it began to descend to the time at which it again reached the surface. The core-extractor was afterwards sent down to bring up the marked core for examination. On its arrival at the surface, the three cutter marks were seen in the form of vertical chases more than three feet each in length on the outside of the cylinder of rock, and the irregularities of the top face completely corresponded with those appearing on the wax cast. By tracing on the upper end of the core, the diameter marked on the wax carrier, it was found to coincide exactly with a line passing through the single chase and midway between the pair of chases, affording a complete proof of the accuracy with which the proper direction had been maintained during lowering.

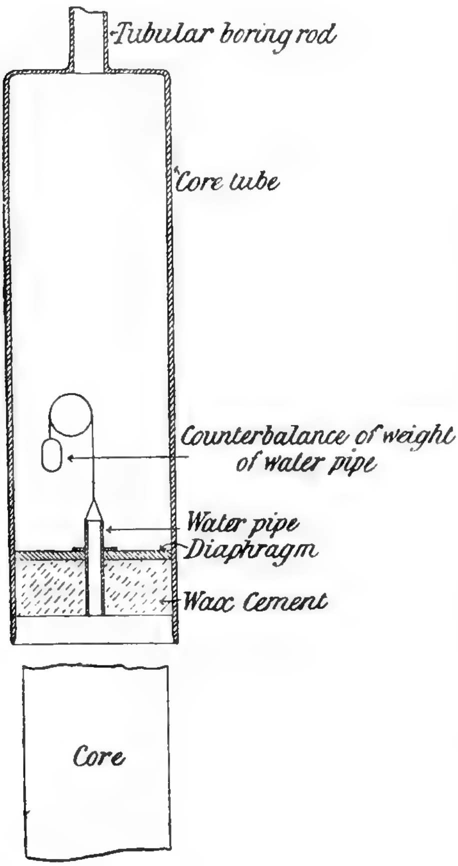
The Committee being anxious to have full confirmation in every respect of the results thus obtained, a further test was devised. The bottom of the hole was faced up quite level by the revolution of suitable cutting edges, and a groove about 6 inches deep was formed around the circumference to receive sediment, thus forming a core to that height. The marked crown (fig. 12) was then prepared by fixing across it, near to the lower edge, a stout bar, on the under side of which were three strong steel points, arranged in a straight line on the marked diameter. One steel point was placed on either side of the centre, at a distance therefrom of 5 inches, the third being at 4 inches from the centre. This served to distinguish one end of the bar from the other. The crown was placed over the hole at the ground level, with the points of the three punches in a line between the two fixed pointers, and was lowered without rotation. The weight of the rods was allowed to come on the points, forcing them a short distance into the stone, after which the crown was raised, again without twist, the proof of this being that it returned with its line of points exactly in their starting position. The core, when broken off and

FIG. 10.



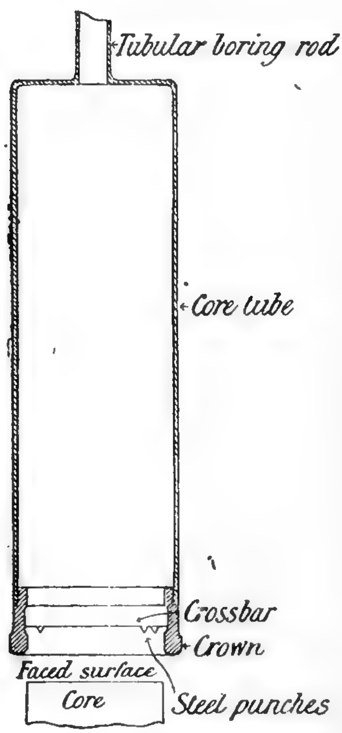
Scale, 1 in. to 2 ft.

FIG. 11.



Scale, 1 in. to 2 ft.

FIG. 12.



Scale, 1 in. to 2 ft.

brought up, exhibited distinctly the three punch marks, indicating the line whose bearing was known. The boring was then continued 2 feet deeper, and an attempt was made to take a wax impression of the markings, but the attempt proved only, that the smooth surface, to which the stone had been planed off in order to its being marked with punches, prevented its yielding a proper recognisable impression, owing probably to adhesion between the two surfaces. The core was therefore detached and drawn up. It came to the surface in several pieces, but, as the lines of fracture extended below the bottom of the shallow groove which existed when the punch marks were made, it was evident that no fracture had taken place before the rock was marked.

It then remained, in the first place, to measure the angle between the direction of dip and the diameter marked on the crown or tube; secondly, to ascertain, by a compass placed beyond the influence of the iron of the boring machinery, the angle between the direction of the fixed pointers to which the marked diameters were set and the magnet meridian; and, thirdly, to learn from an authentic source, the angle then obtaining between the magnetic and the true meridian. By this process it was easily determined that the direction of the dip of the Silurian Rock at Ware, at a depth of 828 feet below the surface, and 31 feet below the top of the stratum, is about one degree west of true south. This is a mean between the angles derived from the two distinct experiments, the variation between them having been 1° 12′. The angle of dip is 41° from the horizon, as was clearly shown by layers of fossils, along which the stone easily fractured.

At Turnford, the general arrangement of the boring apparatus was much the same as at Ware, the only difference of any consequence being, that the rods were connected up in 20 feet instead of in 30 feet lengths. The means employed in determining the direction of dip were somewhat similar to those already described, but greater difficulty was encountered in obtaining reliable results. The complete success that had attended the experiments at Ware warranted the belief that there would not be the same necessity for repetition as when the methods were first tried; but at the same time it was recognised that every result must in some way be corroborated before it could be accepted as correct.

In the first instance, three cutters, for making vertical lines on the outside of the core in the way I have already described, were used. The precautions which had been successfully adopted to guard against the angular motion of the marking tool in its descent and ascent were again employed. But while the said tool was being lowered, an inconsiderate handling of the apparatus by one of the workmen gave rise to the fear that some slight disturbance of the true adjustment of that apparatus had been thereby caused. The marker, on being raised to the surface, came up, not, as had hitherto happened, in the same position as that from which it went down, but showed a rotation of $\frac{15}{16}$ of an inch at the circumference, equal to an angle of 5° 50′. Considering the circumstances attending the interference that had taken place during the lowering, it was considered a fair inference that the core had been marked with the tool turned in the direction in which it came up, not in the position given to it before it was sent down.

An endeavour was then made to obtain a cast in wax cement in much the same manner as at Ware, but this proved a failure owing to a piece that had broken away from the top of the core having fallen against the side of the hole, so that the tube carrying the wax could not be got down over it. Although no information was to be looked for in this instance, still, as a test of the accuracy of the operation, the rods were guided as usual during their ascent, and when they came up were found not to have twisted in the least. The 'extractor' was then lowered to break off and draw up the core. A length of 18 inches only was brought to the surface, and this was in three pieces. Upon each of these pieces the vertical marks of the cutters were found, and the lines were seen to be so cut as to show that when they were made, the parts of the core were yet in their relative positions. The force, moreover, which had to be applied to break the core before it could be raised, as well as the unrubbed condition of the lowest of its pieces, sufficed to prove that all the parts were *in situ* at the time at which they were marked.

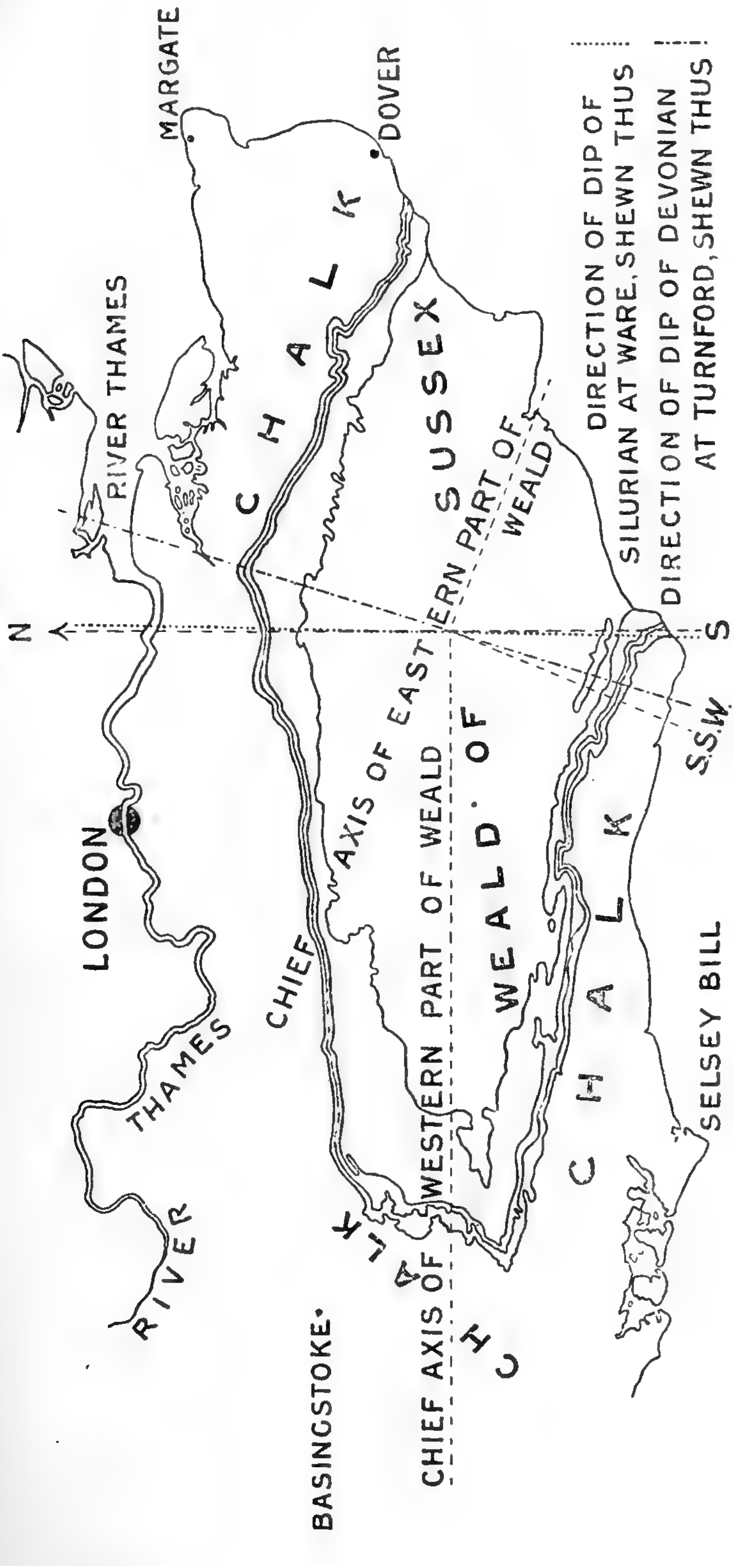
A length of core still remaining fixed at bottom, the wax was sent down again. This time, the bottom of the marking tube lodged for an instant during its descent on the top of a lining tube some 800 feet down, but at once swung off, giving a shock to the rods that caused the radial arm to strike against the staging and turn slightly round on the rod to which it was clamped. The lowering was then completed, the impression taken, and the tube brought up again. It was found to have turned through an angle of 3° 11′ from the direction in which it stood before being lowered. Taking into consideration the fact that when no accidental disturbance occurred no variation was observable, and that the direction of the displacement corresponded with what would be caused by the blow on the arm, it was clearly justifiable to assume that the angular movement observed was entirely attributable to the shifting of the descending pointer at the time of the lodgment on the side of the hole. By taking the bearing of the marked diameter as it returned to the surface instead of as it commenced to go down, the error due to the misfortune was corrected. When the core was brought up there was no difficulty in fitting the wax cast to the rock and transferring the diametrical line.

The two experiments gave identical results, and from this it was computed that the direction of the dip of the Devonian Rock at Turnford at a depth of 994 feet below the surface, and 14 feet below the top of the stratum, is about 17° west of true south. The angle of dip is about 25° from the horizon, as shown by numerous layers of fossils.

It thus appears that at both places these ancient rocks dip in directions lying between south and sou'-sou'-west, and by placing on a geological map of the south-eastern portion of England lines to show the ascertained bearings (fig. 13), it is at once seen that the greatest inclinations of the strata are, roughly speaking, at right angles to the directions of the chief axes of the Weald. Soon after the completion of the borings a statement seems to have been made, without due authority, that the general direction of the dip had been found to be towards the south-east, and, unfortunately, the mistake does not seem to have been publicly refuted until now. It is time that this misconception were removed, for geologists who are interested in the search for coal in the eastern counties evidently attach considerable importance to a correct knowledge of the disposition of these Palæozoic rocks.

Mathematical accuracy could not be expected in operations of this nature, but I believe the bearings of the lines of dip at both places, as herein given, may be looked upon as practically correct, the maximum possible error being not more than one degree east or west. Before the various appliances were perfected there occurred numerous failures to which no reference has been made, but the details given tend to show that no trouble was spared to attain satisfactory results. More than a month was entirely devoted to this ascertainment of the direction of the dip at each place, and in some cases several days were spent in a single operation of lowering and

Fig. 13.


MARGATE
DOVER
RIVER THAMES
CHALK
SUSSEX
AXIS OF EASTERN PART OF WEALD
N
S
S.S.W.
LONDON
RIVER THAMES
CHIEF
CHIEF AXIS OF WESTERN PART OF WEALD
WEALD OF
CHALK
CHALK
BASINGSTOKE
SELSEY BILL
DIRECTION OF DIP OF SILURIAN AT WARE, SHEWN THUS
DIRECTION OF DIP OF DEVONIAN AT TURNFORD, SHEWN THUS

raising the rods. It will be admitted that all was done with due deliberation and care, whilst the composition of the Committee was a guarantee that the methods employed were the best adapted for the purpose.

With regard to the still more important question that the New River Company undertook to solve, viz., that of the existence or the non-existence of the Lower Green Sand beneath the district north of London, it will be generally felt that, although very large sums of money were spent, there is no reason for regretting the expenditure, inasmuch as it decided a question of the greatest importance to the Metropolis.

I am glad to have had the opportunity of making known some of the facts connected with this inquiry, and hope that sufficient evidence has been brought forward to prove that the statements now made with respect to the lie of the Palæozoic rocks at Ware and Turnford may be accepted as perfectly trustworthy.

Physiological Applications of the Phonograph.—Report by the Committee, consisting of Professor JOHN G. MCKENDRICK (*Chairman*), Professor G. G. MURRAY, Mr. DAVID S. WINGATE, *and* Mr. JOHN S. MCKENDRICK, *on the Physiological Applications of the Phonograph, and on the True Form of the Voice-curves made by the Instrument.*

THE work of the Committee, up to the present time, has devolved almost entirely upon Dr. McKendrick, who has embodied the results of his researches in the paper published in the number for July 1895 of the 'Journal of Anatomy and Physiology,' of which the following is an abstract :—

1. *Increasing the Volume of Tone.*—The Committee have succeeded in accomplishing this (1) by the use of conical resonators, of great size, and made of tin or aluminium ; and (2) by combining with the phonograph Alfred Graham's transmitter and loud-speaking telephone.

2. *Study of the Marks on the Cylinder of the Phonograph.*—The physical nature of the marks on the wax cylinder have been investigated in the following three ways : (1) Taking a cast in celloidin of the surface of the cylinder ; (2) taking micro-photographs of portions of the surface of the cylinder ; and (3) recording the curves on a slowly moving surface. The best results were obtained by methods (2) and (3), and these will be found fully described and illustrated by three plates in the 'Journal of Anatomy and Physiology' for July 1895, vol. xxix. (new series ; vol. ix., part iv.), p. 583.

The Committee desire reappointment and an additional grant of 25*l.* It is proposed to carry out the following work during the year 1895–6 :—

1. To continue the investigation of phonographic curves, especially those of the voice, and to submit these to harmonic analysis.

2. To obtain phonographic records of dialects, with the view of ascertaining how far such records could be made available for philological purposes. It has been suggested that such a series of records, deposited in the British Museum, might in after times, long after dialects had become altered or had disappeared, be of great value to philologists.

3. To endeavour to obtain phonographic records of cardiac and respiratory sounds.

The Marine Zoology, Botany, and Geology of the Irish Sea.—Third Report of the Committee, consisting of Professor A. C. HADDON, Professor G. B. HOWES, Mr. W. E. HOYLE, Mr. CLEMENT REID, Mr. I. C. THOMPSON, Mr. A. O. WALKER, Professor F. E. WEISS, *and* Professor W. A. HERDMAN (*Chairman and Reporter*).

As in the previous reports, the work has this year been, of necessity, chiefly carried out by those members of the Committee who live near the scene of action, and have been working at the Port Erin Biological Station. Mr. Clement Reid, however, has been able to undertake in London some geological investigations of the deposits dredged up and sent to the Jermyn Street Museum, and his preliminary report will be found below. Professor Weiss has been prevented by illness from helping in regard to the botany of the district, but hopes still to undertake the work. Mr. Walker and Mr. Thompson have contributed special reports on the Crustacea; the rest of this report has been drawn up by the Chairman of the Committee, with the help of various naturalists whose names are mentioned in connection with their work.

The Committee have carried on their usual exploring work by means of dredging expeditions and otherwise during the year. The specimens obtained have been worked up by specialists, and the most noteworthy additions to the lists are given below. The Committee do not propose, however, to give so detailed a report this year, as they desire, if re-appointed, to draw up for next year's meeting of the Association at Liverpool a final report with complete lists, which they would appropriately illustrate by the exhibition at Liverpool of the collections made, and by dredging expeditions, both from Liverpool and Port Erin, to enable the biologists and geologists present at the meeting to judge of the work of the Committee and examine their results.

The following, therefore, is merely a brief outline of the work undertaken during the past year; with a discussion—for which the chairman is chiefly responsible—of some parts of the investigations.

DREDGING EXPEDITIONS.

The Committee have organised the following expeditions since the last report:—

I. August 19, 1894.—Hired steam trawler 'Lady Loch.' Localities dredged, around the Calf Island and to the west of Port Erin, at depths of about 20 fathoms.

II. August 25, 1894.—Hired steam trawler 'Albatross.' Localities dredged, the open sea between Isle of Man and Ireland, at depths down to over 50 fathoms. On this occasion some specimens of the tube-building polynoid worm *Panthalis Oerstedi* were obtained, for Mr. Watson's observations on the building habits, which have since been published.[1] We also on this occasion photographed various kinds of deposits and assemblages of animals as they came up in the dredge.

III. September 30, 1894.—Hired steam trawler 'Lady Loch.' Localities dredged, along the west side of the Isle of Man, at depths down to 60 fathoms.

[1] *Trans. Biol. Soc.*, Liverpool, vol. ix. p. 169.

IV. April 15, 1895.—Hired steam trawler 'Lady Loch.' Localities dredged, to the west and north-west of Port Erin, at depths of 20 to 40 fathoms.

V. April 25, 1895.—Hired steam trawler 'Lady Loch.' Localities dredged, to the west and south of Port Erin at depths of 30 to 40 fathoms.

At one spot, 6 miles S.E. of Calf Island, 34 fathoms, bottom sand gravel and shells, such a rich haul was obtained that the trawl-net tore away, and only a small part of the contents was recovered. That contained, however, a number of specimens of the rare shrimp *Pontophilus spinosus*, Leach, along with *Munida rugosa*, *Ebalia tumefacta* and *E. tuberosa*, *Xantho tuberculatus*, *Pandalus brevirostris*, *Anapagurus Hyndmanni*, *Campylaspis* sp., and *Melphidippella macera* amongst crustaceans, and the following Echinodermata :—*Palmipes membranaceus*, *Porania pulvillus*, *Stichaster rosea*, *Lluidea Savignii*, *Synapta inhærens*, and other holothurians. There were also, of course, many mollusca, worms, &c., and an unfamiliar actinian, which Professor Haddon considers to be probably his new species *Paraphellia expansa*, hitherto only known from deep water off the south-west coast of Ireland.

VI. June 1, 1895.—Hired steam trawler 'Lady Loch.' Localities dredged, Calf Sound and off S.E. of Isle of Man, at depths of 15 to 20 fathoms.

VII. June 23, 1895.—Hired steam trawler 'Rose Ann.' Localities dredged, to the W. and N.W. of Peel and Ballaugh, on the 'North Bank,' at depths about 20 fathoms.

VIII. August 3, 1895.—Lancashire Sea Fisheries steamer 'John Fell.' Localities dredged and trawled, Red Wharf Bay and off Point Lynas, on north coast of Anglesey, at depths of 6 to 17 fathoms.

IX. August 19, 1895.—Steamer 'John Fell.' Localities dredged, Carnarvon Bay, on south coast of Anglesey ; depths 15 to 18 fathoms.

ADDITIONS TO THE FAUNA.

In addition to these 'steamer' expeditions there has been frequent dredging and tow-netting from small boats, and a good deal of 'shore collecting.'

Amongst the more noteworthy animals collected in the district during the year are the following :—

Porifera.

The sponge, *Myxilla irregularis*, Bowerbank, previously only known from the Diamond Ground, Hastings, was found by Dr. Hanitsch at Port Erin and at Fleshwick in August and September 1894.

Cœlenterata.

Mr. Edward T. Browne has drawn up a list of thirty-four species of Medusæ which are found in the district, and of these the following are specially noteworthy :—*Amphicodon fritillaria* (carrying young hydroids in the umbrellar cavity), *Dysmorphosa minima*, *Cytæandra areolata* (?), *Lizzia blondina* *Laodice calcarata* (new to European seas) and *Eutima* *insignis*.[1] Miss L. R. Thornely reports the addition of *Perigonimus repens* to the list of hydroids. The yellow variety of *Sarcodictyon* (*Clavularia*) *catenata*, of which we dredged several colonies on August 25, off the north-west of the Calf Island, in 22 fathoms, is an interesting addition to our fauna. It has only been found before in Loch Fyne and at two other spots on the west coast of Scotland. This is certainly the *Sarcodictyon agglomeratum* of Forbes and Goodsir.

Vermes.

Mr. Beaumont reports the following additions to the list of Nemertida :—*Amphiporus pulcher*, *A. dissimulans*, *Tetrastemma flavidum*, *Prosorhochmus Claparédii*, *Micrura purpurea*, *M. fasciolata*, *M. candida*, and *Cerebratulus fuscus*.

During this summer we have dredged from a gravelly bottom, at 10 to 15 fathoms, in two localities near Port Erin, a species of *Polygordius*, either *P. apogon*, M'Intosh, or a new species.

Amongst Polychæta Mr. Sumner records *Arenicola ecaudata* and *Amphitrite Johnstoni* ; Mr. Arnold Watson *Autolytus Alexandri* (with egg-sac) and many larval *Pectinaria*, in membranous tube $\frac{1}{23}$ inch long.

Amongst Polyzoa Miss Thornely reports the rare *Triticella Boeckii*, found attached to the prawn *Calocaris Macandreæ*, from the deep mud off Port Erin.

Mollusca.

The following Opisthobranchiata may be mentioned :—*Scaphander lignarius*, *Pleurobranchus plumula*, *Oscanius membranaceus*, *Elysia viridis*, *Runcina Hancocki*, *Lamellidoris aspera*, *Polycera Lessonii*, *Cuthona aurantiaca*, *Coryphella gracilis*, *C. lineata* and *C. Landsburgii*, *Facelina Drummondi*, *Eolis arenicola*, *Cratena concinna* and *C. olivacea*, *Galvina Farrani*, *Embletonia pulchra*, *Actæonia corrugata*, *Limapontia nigra*, *Lomanotus genei*, and a curious little *Doris*, which has been dredged several times in the neighbourhood of Port Erin, and is still unidentified. It may possibly be an unknown species.

Crustacea.

This section is contributed by Mr. I. C. Thompson and Mr. A. O. Walker, Mr. Thompson taking the Copepoda and Mr. Walker the higher forms. The following additional records of Copepoda have, however, been supplied by Mr. Andrew Scott since Mr. Thompson's report was drawn up, viz. :—*Sunaristes paguri*, Hesse ; *Stenhelia reflexa*, T. Scott ; *Laophonte intermedia*, T. S.; *L. propinqua*, T. and A. S.; *Cletodes similis*, T. S.; *Modiolicola insignis*, Aur. ; and *Dermatomyzon gibberum*, T. and A. S. : all new to our fauna.

Copepoda.

In the last report mention was made of a new copepod found by Mr. I. C. Thompson in dredged material taken outside Port Erin at 15 fathoms. This has since been described by Mr. Thompson ('Trans. Liverpool Biol. Soc.,' vol. ix. p. 96, plates vi. and vii.) as *Pseudocyclopia stephoides*.

It was by no means easy to decide into which genus to place this

[1] For Mr. Browne's observations on these and other species see vol. iv. of *Fauna of Liverpool Bay*.

well-marked species, as it has strong points of resemblance in common with the three genera, *Pseudocalanus*, *Stephos*, and *Pseudocyclopia*. With *Pseudocyclopia* it agrees in all points excepting in the number of joints in the anterior antennæ, and the primary branch of the posterior antennæ, and as in general appearance and in the first four pairs of swimming feet it strongly resembles *Pseudocyclopia*, it was decided provisionally to place it in that genus. Its fifth pair of feet, however, are more like those of *Stephos*. In the 'Twelfth Annual Report of the Fishery Board for Scotland' Mr. Thomas Scott added a new species belonging to this genus recently found by him in the Forth area. As the genus *Pseudocyclopia* forms a sort of missing link between the families Calanidæ and Misophriidæ, Mr. Scott has wisely constituted a new family, the Pseudocyclopiidæ, for its reception. The species of *Pseudocyclopia* described by him having respectively sixteen and seventeen joints in the anterior antennæ, he has made that number a family character. The species here described has, however, twenty joints in the anterior antennæ, and as it otherwise agrees in all respects with the family characters of Pseudocyclopiidæ, Mr. Thompson suggested that the words 'sixteen to seventeen jointed' be altered to 'sixteen to twenty jointed' as a character of this new family, with which Mr. Scott at once concurred.

The following species of Copepoda, viz., *Diosaccus propinquus*, T. and A. Scott; *Ameira exigua*, T. Scott; *A. longiremis*, T. Scott; *Laophonte inopinata*, T. Scott; *Pseudowestwoodia pygmæa*, T. and A. S.; and possibly a new *Laophonte* and one or two other doubtful species were obtained from washings from sponges collected by Dr. Hanitsch at Port Erin in August 1894, and are new to the district.

One specimen of *Modiolicola insignis*, Aurivillius, also new to the district, was found in the washings of dredged material taken some miles off Peel in June 1895. This species is known as a messmate within the shell of the 'horse mussel' (*Mytilus modiolus*), and has been recorded by Canu ('Les Copep. du Boulon.,' p. 238, plate xxx. fig. 14–20), and more recently by Mr. Scott from the Firth of Forth.

Mr. A. O. Walker reports as follows on the HIGHER CRUSTACEA :—

PODOPHTHALMATA.

Munida rugosa, Fabr.—One young, April 25, 1895, station 3.

Crangon (*Pontophilus*) *spinosus*, Leach.—Several, April 25, 1895, station 3. Colour: whitish, freckled with reddish-brown on the antennal scales and legs; sparsely on the front and hind margins of thorax and first three abdominal segments, and densely on the last three abdominal segments, hind margin of third and generally front margin of fourth abdominal segments and proximal half of telson and lateral appendages milk-white. Length, $2\frac{1}{4}$ in.

CUMACEA.

*[*] *Cuma pulchella*, Sars.—Little Orme, 4–7 fathoms, rocks and sand, September 14, 1894.

Cumopsis Goodsiri, Sars.—With the last species.

* Those species marked with a star are new to the British fauna.

**Hemilamprops assimilis*, Sars.—Off Galley Head, Co. Cork, November 24, 1894.

**Eudorella nana*, Sars.—Off Port Erin, August 7, 1894, stations 1 and 2; 30–38 f. mud.

**Diastylis rugosoides*, n. sp.—Galley head, six males. Very near *D. rugosa* (Sars), from which it differs in the absence of the vertical plica on the carapace, and in the strong dorso-lateral teeth on the first three pleon segments.

Isopoda.

Cirolana borealis, Lilljeborg.—Galley Head ; off Port Erin, April 25, 1895, station 2.

Amphipoda.

A small collection has been made by Mr. R. L. Ascroft, of Lytham, from trawl refuse and a tow-net attached to the trawl beam when working in the southern part of the Irish Sea off Galley Head. The most interesting feature of it is that nearly all the specimens are adult males, in which condition amphipods are less often taken than any other. This may perhaps be attributed to their having been taken late in November, a season at which collectors do not generally dredge.

Parathemisto oblivia, Kröyer.—Galley Head.

Callisoma crenata, Bate.—Galley Head ; off Port Erin, April 25, 1895, station 1.

Hippomedon denticulatus, Bate.—Galley Head.

Orchomenella ciliata, Sars.—Galley Head.

Tryphosites longipes, Bate.—Galley Head.

Lepidepecreum carinatum, Bate.—Galley Head.

**Paraphoxus oculatus*, Sars.—Off Port Erin, April 25, 1895, stations 1 and 2.

Harpinia lævis, Sars.—Off Port Erin, July 8, 1894, 7½ miles west of Niarbyl Point, 45 f. mud.

Epimeria cornigera, Fabr.—Galley Head.

Syrrhaë fimbriata, Stebbing and Robertson.—Off Port Erin, April 25, 1895, station 1.

Leptocheirus hirsutimanus, Bate=*L. pilosus* (Sars nec Zaddach).—Two miles south-east of Kitterland, 17 f., May 27, 1894.

Photis longicaudatus, Bate.—Off Port Erin, April 25, 1895, stations 2 and 3.

**Photis pollex*, n. sp.—Colwyn Bay, shore; Little Orme; Menai Straits, 5–10 f. This species is intermediate between *Photis Reinhardi* (Kröyer) and *P. tenuicornis* (Sars). The hind margin of the propodos of the second gnathopod in the male is distally produced into a thumb-like process which has its origin much nearer the carpus than in *P. Reinhardi*.

Podocerus ocius, Bate.—Sponge *débris*, Port Erin, 1894.

SOME STATISTICS OF DREDGING RESULTS.

During this year's work we have been paying some attention to the actual numbers of individuals, species, and genera brought up in particular hauls of the dredge or trawl. Our attention has recently been directed to the matter by some statements in Dr. Murray's 'Summary' volumes of the 'Challenger' Expedition Report which seemed not to be in accord with our experience. Dr. Murray quotes the statistics of the Scottish Sea Fisheries Board to show that only 7·3 species of invertebrates and 8·3 species of fishes are captured on the average by the 'Garland's' beam trawl;[1] and he cites as an example of a large and varied haul from deep water one taken by the 'Challenger' at Station 146 in the Southern Ocean, at a depth of 1,375 fathoms, with a 10-foot trawl dragged for at most 2 miles during at most two hours, when 200 specimens were captured belonging to fifty-nine genera and seventy-eight species. Murray then goes on to say: 'In depths less than 50 fathoms, on the other hand, I cannot find in all my experiments any record of such a variety of organisms in any single haul, even when using much larger trawls and dragging over much greater distances.' He must have been singularly unfortunate in his experiments, as our experience of dredging in the Irish Sea is that quite ordinary hauls of the dredge or very small trawl (only 4-foot beam) contain often more specimens, species, and genera than the special case cited from the 'Challenger' results. On the first of our expeditions after the appearance of Dr. Murray's volumes we counted the contents of the first haul of the trawl. The particulars are as follows:—June 23, 7 miles W. of Peel, on North Bank, bottom sand and shells, depth 21 fathoms, trawl 4 feet beam, down for 20 minutes; 232 specimens were counted, but there may well have been another 100; they belonged to at least 112 species and 103 genera, a larger number in every respect—specimens, species, and genera—than the 'Challenger' haul quoted. The list of these species is here given, and the marine zoologist will see at a glance that it is nothing out of the way, but a fairly ordinary assemblage of not uncommon animals such as is frequently met when dredging in from 15 to 30 fathoms.

SPONGES:
- *Reniera*, sp.
- *Halichondria*, sp.
- *Cliona celata*
- *Suberites domuncula*
- *Chalina oculata*

CŒLENTERATA:
- *Dicoryne conferta*
- *Halecium halecinum*
- *Sertularia abietina*
- *Coppinia arcta*
- *Hydrallmania falcata*
- *Campanularia verticillata*
- *Lafoëa dumosa*
- *Antennularia ramosa*
- *Alcyonium digitatum*
- *Virgularia mirabilis*
- *Sarcodictyon catenata*
- *Sagartia*, sp.
- *Adamsia palliata*

ECHINODERMATA:
- *Cucumaria*, sp.
- *Thyone fusus*
- *Asterias rubens*
- *Solaster papposus*
- *Stichaster roseus*
- *Porania pulvillus*
- *Palmipes placenta*
- *Ophiocoma nigra*
- *Ophiothrix pentaphyllum*
- *Amphiura Chiajii*
- *Ophioglypha ciliata*
- *O. albida*
- *Echinus sphæra*
- *Spatangus purpureus*
- *Echinocardium cordatum*
- *Brissopsis lyrifera*
- *Echinocyamus pusillus*

VERMES:
- *Nemertes Neesii*
- *Chætopterus*, sp.
- *Spirorbis*, sp.
- *Serpula*, sp.
- *Sabella*, sp.
- *Owenia filiformis*
- *Aphrodite aculeata*
- *Polynoe*, sp.

CRUSTACEA:
- *Scalpellum vulgare*
- *Balanus*, sp.
- *Cyclopicera nigripes*
- *Acontiophorus elongatus*

[1] It has been shown in the Presidential Address to Section D at Ipswich that Dr. Murray must have misunderstood the observations in question.

Artotrogus magniceps
Dyspontius striatus
Zaus Goodsiri
Laophonte thoracica
Stenhelia, sp.
Lichomolgus forficula
Anonyx, sp.
Galathea intermedia
Munida bamffica
Crangon spinosus
Stenorhynchus rostratus
Inachus dorsettensis
Hyas coarctatus
Xantho tuberculatus
Portunus pusillus
Eupagurus Bernhardus
E. Prideauxii
E. cuanensis
Eurynome aspera
Ebalia tuberosa

POLYZOA:
Pedicellina cernua
Tubulipora, sp.
Crisia cornuta
Cellepora pumicosa and three or four undetermined species of Lepralids
Flustra securifrons
Scrupocellaria reptans
Cellularia fistulosa

MOLLUSCA:
Anomia ephippium
Ostrea edulis
Pecten maximus
Pecten opercularis
P. tigrinus
P. pusio
Mytilus modiolus
Nucula nucleus
Cardium echinatum
Lissocardium norvegicum
Cyprina islandica
Solen pellucidus
Venus gallina
Lyonsia norvegica
Scrobicularia prismatica
Astarte sulcata
Modiolaria marmorata
Saxicava rugosa
Chiton, sp.
Dentalium entale
Emarginula fissura
Velutina lævigata
Turritella terebra
Natica Alderi
Fusus antiquus
Aporrhais pes-pelicani
Oscanius membranaceus
Doris, sp.
Eolis coronata
Tritonia plebeia

TUNICATA:
Ascidiella virginea
Styelopsis grossularia
Eugyra glutinans
Botryllus sp.
B. sp.

In order to get another case, on different ground, not of our own choosing, on the first occasion after the publication of Dr. Murray's volumes, when the Reporter was out witnessing the trawling observations of the Lancashire Sea Fisheries steamer 'John Fell,' he counted, with the help of Mr. Andrew Scott and the men on board, the results of the first haul of the shrimp trawl. It was taken on July 23 at the mouth of the Mersey estuary, inside the Liverpool Bar, on very unfavourable ground: bottom muddy sand, depth 6 fathoms. The shrimp trawl ($1\frac{1}{2}$-inch mesh) was down for 1 hour, and it brought up over seventeen thousand specimens referable to the following thirty-nine species belonging to thirty-four genera :—

Solea vulgaris
Pleuronectes platessa
P. limanda
Gadus morrhua
G. æglefinus
G. merlangus
Clupea spratta
C. harengus
Trachinus vipera
Agonus cataphractus
Gobius minutus
Raia clavata
R. maculata
Mytilus edulis
Tellina tenuis
Mactra stultorum
Fusus antiquus
Carcinus mænas
Portunus, sp.
Pagurus Bernhardus
Crangon vulgaris
Sacculina, sp.
Amphipoda (undetermined)
Longipedia coronata
Ectinosoma spinipes
Sunaristes paguri
Dactylopus rostratus
Cletodes limicola

Caligus, sp.
Flustra foliacea
Aphrodite aculeata
Pectinaria belgica
Nereis, sp.
Asterias rubens
Hydractinia echinata
Sertularia abietina
Hydrallmania falcata
Aurelia aurita
Cyanæa, sp.

These numbers have been exceeded on many other hauls in the ordinary course of work by the Fisheries steamer in Liverpool Bay. For example, on this occasion the fish numbered 5,943, and I have records of hauls in which the fish numbered over 20,000. The shrimps probably number as many again, and if the starfishes and other abundant invertebrates are added the total must sometimes reach such enormous numbers as from 45,000 to 50,000 specimens in a single haul of the trawl in shallow water, not including microscopic forms. Can any of Dr. Murray's hauls on the deep mud beat these figures?

On the next occasion, when on board the 'John Fell,' on our own expedition of August 3, two members of this committee (A. O. Walker and W. A. Herdman) identified the species brought up in the first haul of the trawl (5-inch mesh), taken in Red Wharf Bay, Anglesey, at a depth of 4–7 fathoms. They were 78 species, belonging to 67 genera, as follows:—

Solea vulgaris
S. lutea
Pleuronectes platessa
P. limanda
P. flesus
Gadus morrhua
G. æglefinus
G. merlangus
Callionymus lyra
Raia maculata
Fusus antiquus
Buccinum undatum
Natica Alderi
Pleurotoma, sp.
Philine, sp.
Eolis, sp.
Polycera quadrilineata
Corbula gibba
Mactra stultorum
Scrobicularia alba
Portunus depurator
Corystes cassivelaunus
Hyas coarctatus
Stenorhynchus phalangium
Eupagurus Bernhardus
Crangon vulgaris
Pseudocuma cercarea
Diastylis Rathkei
D. spinosa
Balanus balanoides
Paratylus Swammerdammii
Harpinia neglecta
Ampelisca lævigata
Monoculodes longimanus
Amphilochus melanops
Pariambus typicus
Achelia echinata
Aphrodite aculeata
Nereis, sp.
Terebella, sp.
(?) *Syllis*, sp.
Serpula, sp.
Spirorbis, sp.
Cellaria fistulosa
Flustra foliacea
Eucratea chelata
Scrupocellaria reptans
Bugula, sp.
Cellepora pumicosa
C. avicularis
Porella compressa
Mucronella Peachii
Membranipora membranacea
M. pilosa
Alcyonidium gelatinosum
Vesicularia spinosa
Gemellaria loricata
Lichenopora hispida
Crisia eburnea
C. cornuta
Idmonea serpens
Asterias rubens
Amphiura squamata
Ophioglypha albida
Tealia crassicornis
Alcyonium digitatum
Clytia Johnstoni
Lafoëa dumosa
Hydrallmania falcata
Halecium halecinum
Antennularia ramosa
Coppinia arcta
Sertularella polyzonias
Sertularia abietina
S. argentea
Diphasia rosacea
D. tamarisca
Tubularia indivisa

A point which comes out in making complete lists, such as the above, of the contents of the net on one haul is the relatively large number of genera represented by the species.[1] In the haul, quoted above, from the expedition of June 23 the 112 species were referred to 103 genera; in the haul from the Fisheries steamer on July 23 the 39 species obtained belong to 34 genera; and in the haul on August 3 there were 78 species and 67 genera. Taking a few instances of particular groups—on August 25, 1894, the 12 species of Tunicata taken in one haul represented 10 genera; and Mr. Walker reports the following numbers of species and genera in hauls of the higher Crustacea:—March, 1893, off Rhos, shallow, 19 species in 18 genera; May 1893, off Rhos, 2 fathoms, 24 species in 21 genera; July 1893, off Little Orme, 5 to 10 fathoms, 31 species in 28 genera; October 1893, off Little Orme, 4 to 10 fathoms, 41 species in 36 genera; September 1894, off Little Orme, shallow, 39 species in 35 genera; and April 1895, off Port Erin, 34 fathoms, 40 species in 35 genera.

These figures are particularly interesting in their bearing on the Darwinian principle that an animal's most potent enemies are its own close allies. Is it then the case, as the above cited instances suggest, that the species of a genus rarely live together; that if in a haul you get half-a-dozen species of lamellibranchs, amphipods, or annelids they will probably belong to as many genera, and if these genera contain other British species these will probably occur in some other locality, perhaps on a different bottom, or at another depth? It is obviously necessary to count the total number of genera and species of the groups in the local fauna, as known, and compare these with the numbers obtained in particular hauls. That has been done to some extent with the 'Fauna' of Liverpool Bay, and the following instances may be taken as samples. The known number of species of higher Crustacea is 90, and these fall into 60 genera. So the genera are to the species as 2 to 3, whereas in the collections quoted from Mr. Walker above the genera are to the species on the average about as 28 to 31, or nearly 7 to 8. Again, the total number of species of Tunicata is 46, and these are referred to 20 genera; while in the case given above (August 25, 1894) the 12 species taken on one spot represented 10 genera, or, a little over a quarter of the species represented half the genera. These, and many other cases which we might quote, seem to show that a disproportionately large number of genera is represented by the assemblage of species at one spot, which means that closely related species are, as a rule, not found together. We know of some cases, however, of allied species occurring together, but these do not necessarily affect the general argument. It is possible also that sessile animals, such as hydroids and polyzoa, may form a partial exception, and may differ from wandering forms in their method of competition. We are accumulating further statistics on these points.

THE SUBMARINE DEPOSITS.

In last year's report the nature of the deposits forming on the floor of the Irish Sea was discussed in a preliminary manner. During this season's work the bottom brought up on each occasion has been carefully noted and a sample kept for future study in the Jermyn Street Museum. One point which this collection of deposits from comparatively shallow

[1] Dr. Murray, in the 'Challenger' Summary, notes this fact in the case of deep-sea hauls, but does not seem to recognise its application to shallower waters.

shore waters seems to bring out is that the classification of submarine deposits into 'terrigenous' and 'pelagic,' which was one of the earliest oceanographic results of the 'Challenger' Expedition, and which is still adhered to in the latest 'Challenger' volumes as an accepted classification, does not adequately represent or express fully the facts. Terrigenous deposits are supposed to be those formed round continents from the waste of the land, and are stated to contain on the average 68 per cent. of silica. Pelagic deposits are those formed in the open ocean from the shells and other remains of animals and plants living on the surface of the sea above.

Ordinary coast sands and gravels and muds are undoubted *terrigenous* deposits. Globigerina and radiolarian oozes are typical *pelagic* deposits. But in our dredgings in the Irish Sea, where the deposits ought all to be purely terrigenous, we meet with several distinct varieties of bottom which are not formed mostly from the waste of the land, and do not contain anything like 68 per cent. of silica; but, on the contrary, are formed very largely of the remains of plants and animals, and may contain as little as 23 per cent. of silica. Such are the nullipore bottoms, and the shell sand and shell gravel met with in some places, and the sand formed of comminuted spines and plates of echinoids which we have found off the Calf Island. These deposits are really much more nearly allied in their nature, and in respect of the kind of rock which they would probably form if consolidated, to the calcareous oozes amongst pelagic deposits than they are to terrigenous deposits, and yet they are formed on a continental area close to land in shallow water. Moreover, although agreeing with the pelagic deposits in being largely organic in origin, they differ in being derived not from surface organisms, but from plants (the nullipores) and animals which lived on the bottom. Consequently the division of deposits into 'terrigenous' and 'pelagic' ought to be modified or replaced by the following classification:—

1. *Terrigenous* (Murray's term)—where the deposit is formed chiefly of mineral particles derived from the waste of the land.
2. *Neritic*[1]—where the deposit is chiefly of organic origin, and is derived from the shells and other hard parts of the animals and plants living on the bottom.
3. *Planktonic* (Murray's pelagic)—where the greater part of the deposit is formed of the remains of free-swimming animals and plants which lived in the sea above the deposit.

Mr. Clement Reid, F.G.S., to whom the deposits are handed over for detailed examination, reports as follows:—

'The series of dredgings examined since the last report is most interesting from a geological point of view. One is again struck by the common occurrence of loose angular stones at places and depths apparently well beyond the reach of any bottom drift—at least beyond the reach of currents likely to move such coarse material. This stony sea-bed is in all probability the result of submarine erosion of glacial deposits. Its occurrence renders comparison between recent marine deposits of these latitudes and Tertiary deposits a task of peculiar difficulty; for not only is the nature of the true marine sediments masked, but the fauna also must be

[1] Adopted from Haeckel's term for the zone of shallow water marine fauna (see *Plankton-Studien*, Jena, 1890; also Hickson's *Fauna of Deep Sea*, 1894).

greatly altered. It is evident that numerous species which need a firm base on which to affix themselves will be encouraged by a stony bottom; while in a Tertiary deposit, formed under identical conditions, except for the absence of stones, they may be entirely missing, having nothing but dead shells to which to attach themselves.

'Notwithstanding this peculiarity of most of the dredgings, a few samples may well be compared with our Older Pliocene (Coralline Crag). I would particularly draw attention to certain localities where material almost entirely of organic origin has been obtained. Of these perhaps the most interesting are some samples full of *Cellaria fistulosa* (found to the south-east of the Calf Sound, 20 fathoms). They are in many respects strikingly like certain parts of the Coralline Crag. The more ordinary type of Coralline Crag, with its extremely varied polyzoon fauna, we cannot yet match in British seas: it was probably formed, as the mollusca indicate, in a sea several degrees warmer than ours.

'It was hoped that in the course of these dredgings some light might be thrown on the Tertiary strata underlying the bed of the Irish Sea, for in the North Sea the dredge occasionally brings up hauls of Tertiary fossils. This expectation has not yet been realised; but possibly, by dredging in the channels where the submarine scour is greatest, such deposits may yet be reached. It is very important to obtain some knowledge of the Tertiary bed of the Irish Sea, for Irish Pleistocene deposits contain a considerable admixture of extinct forms, which may be derived from Tertiary deposits below the sea-level. The Glacial Drift of Aberdeenshire contains Pliocene Volutes and Astartes, derived from some submarine deposit off the Aberdeenshire coast. The so-called "Middle Glacial Sands" of Norfolk are full of shells which I now believe to be derived from some older deposit, probably beneath the sea.'

The important influence of the shore rocks upon the littoral fauna has not been neglected, and lists and observations are accumulating, but that subject is left over for a fuller discussion in the final report next year.

OTHER INVESTIGATIONS.

Several new lines of investigation have been started during the year, and are still in progress. One of these may be called the 'larval-attachment inquiry,' and consists in sinking in various parts of the bay an apparatus composed of a rope weighted at one end and buoyed at the other, and having a number of slips of glass, slate, wood, &c., attached at equal distances along its length. These ropes are hauled up and examined periodically, and may be expected when further observations have been taken to give information as to the times and modes of attachment of the larvæ of various species, and also as to the most suitable substances for particular kinds of larvæ to settle down upon. So far glass seems the favourite substance, and a surprisingly large number of algæ compared with the animals have appeared.

'Drift Bottles' and Surface Currents.

In connection with the investigation of the surface life, in discussing the appearance and disappearance of swarms of certain Copepoda and Medusæ, and in considering the possible influence of the movements of such food matters upon the migrations of fishes, and also in connection with the movements of the fish ova and floating embryos, it occurred to us that it would be worth while to try to ascertain the set of the chief currents, tidal[1] or otherwise, such as the movement of surface waters caused by prevalent winds. The Prince of Monaco started a few years ago the system of distributing over the North Atlantic large numbers of small floating copper vessels, with the object of finding out where they drifted to. This plan we have adopted, with slight modifications, and in September 1894 we started the distribution of what may be called 'drift bottles' over the Irish Sea. A small, strong, buoyant bottle, measuring 7·5 cm. by 1·8 cm., which seemed well suited for the purpose, and which costs only 7*s.* per gross, was selected. A notice was drawn up, as follows,[2] to go in the bottles, and a large number of copies were printed and numbered consecutively.

> Anyone who finds this is earnestly requested to write the place, and date when found, in the space (on the other side) for the purpose, place the paper in an envelope, and post it to
>
> PROFESSOR HERDMAN,
> University College,
> LIVERPOOL.
>
> No...........
> Postage need not be prepaid.
>
> Turn over.
>
> [OTHER SIDE.]
> Please write distinctly, and give full particulars.
> LOCALITY, where found ....
> ....
> ....
> DATE, when found ....
> Name and address of sender
> ....
> ....

A paper was then placed in each bottle, so folded that the number could be readily seen through the glass, the cork was well pressed down, and dipped in melted paraffin. Some hundreds of these bottles have, since September 30, been dropped into the sea in various parts of our area, a record being kept of the locality and time when each was set free. Many have been let off at intervals of a quarter of an hour from the Isle of Man steamer in crossing to Douglas and back, and from our trawler when dredging between Port Erin and Ireland. Some dozens have been let off from Mr. Alfred Holt's steamers in going round to Holyhead and in coming down from Greenock. Mr. Dawson on the Fishery steamer 'John Fell' has distributed a number along the coast in the northern part of the district, and others have been set free at stated intervals during the rise and fall of the tide from the Morecambe Bay Light Vessel, and Lieutenant Sweny has kindly arranged to have a similar periodic distribution from the Liverpool North-west Light Vessel. Altogether, nearly 33 per cent., or about one in three of the papers distributed, have been

[1] The tidal currents of the district are already to some extent known, and are marked in the charts and given in books of sailing directions, as Admiral Beechy's *Tidal Streams of the Irish Sea*; but we desire to ascertain the resultant currents from all influences which would affect the drift of small floating bodies.

[2] Afterwards printed stamped postcards were substituted for these papers, and a slightly larger size of bottle was used.

subsequently picked up on the shore and returned duly filled in and signed. They come from various parts of the coast of the Irish Sea—Scotland, England, Wales, Isle of Man, and Ireland. Some of the bottles have gone quite a short distance, having evidently been taken straight ashore by the rising tide. Others have been carried an unexpected length, *e.g.*, one (No. 35), set free near the Crosby Light Vessel, off Liverpool, at 12.30 P.M., on October 1, was picked up at Saltcoats, in Ayrshire, on November 7, having travelled a distance of at least 180 miles [1] in thirty-seven days; another (H. 20) was set free near the Skerries, Anglesey, on October 6, and was picked up, one mile north of Ardrossan, on November 7, having travelled 150 miles in thirty-one days; and bottle No. 1, set free at the Liverpool Bar on September 30, was picked up at Shiskin, Arran, about 165 miles off, on November 12. On the other hand, a bottle (J. F. 34) set free on November 7, at the Ribble Estuary, was picked up on November 12 at St. Anne's, having gone only 4 miles.

It would be premature as yet—until many more dozens or hundreds have been distributed and returned—to draw any very definite conclusions. It is only by the evidence of large numbers that the vitiating effect of exceptional circumstances, such as an unusual gale, can be eliminated. Prevailing winds, on the other hand, such as would usually affect the drift of surface organisms, are amongst the normally acting causes which we are trying to ascertain. We may, however, state, for what they are worth, the following results obtained so far:—(1) Nearly 50 per cent. of the bottles found have been carried across to Ireland, and they are chiefly ones that had been set free in the southern part of the district (between Liverpool and Holyhead) and off the Isle of Man; (2) the bottles set free along the Lancashire coast and in Morecambe Bay seem chiefly to have been carried to the south and west, to about Mostyn and Douglas; (3) it is apparently only a few that have been carried out of the district through the North Channel. It is interesting to learn that the Fishery Board for Scotland has also commenced a similar inquiry by the distribution of floating bottles in the Scottish territorial waters. No account of their experiment has yet appeared, but it will be of some importance to compare results with them, say, at the end of the first year's work.

The Committee apply to be reappointed for one additional year, with a grant of 50*l.*, to enable them to carry on their investigations and draw up a final report.

The Zoology of the Sandwich Islands.—Fifth Report of the Committee, consisting of Professor A. NEWTON (*Chairman*), Dr. W. T. BLANFORD, Dr. S. J. HICKSON, Professor C. V. RILEY, Mr. O. SALVIN, Dr. P. L. SCLATER, Mr. E. A. SMITH, *and* Mr. D. SHARP (*Secretary*).

THE Committee was appointed in 1890, and has been annually re-appointed. Acting jointly with that appointed by the Royal Society for the same purposes, it decided, as stated in its Report made at Oxford, that Mr. Perkins should return home from the Sandwich Islands. He accord-

[1] More probably, very much further, as during that time it would certainly be carried backwards and forwards by the tide.

ingly arrived in England last autumn, and for the next four months was engaged in overhauling the very large collections he had previously made. These proved to be of great importance, and the Committee has gratefully to acknowledge the zeal and perseverance displayed by Mr. Perkins in carrying out its wishes. As was to be expected, close examination made it evident that much still remained to be done to complete the Committee's work of exploration. From the information given by Mr. Perkins, it was clear that, unless the deficiencies be made good without loss of time, this will never be done, the extinction of many members of the still existing Fauna being not only inevitable, but immediate. The Committee, believing that it would be a matter for serious regret if the task, on which so much labour and money have already been expended, were left unfinished, resolved to send Mr. Perkins out again. With this object it applied to the Council of the Royal Society for the sum of 100*l.*, which was granted, in order that he might start without delay, so as to take advantage of the most favourable season of the present year. Mr. Perkins reached Honolulu before the end of March last, and has since been working, chiefly in the islands of Kauai and Hawaii.

The Committee has also to report that a proposal has been received from the trustees of the Bernice P. Bishop Museum in Honolulu, offering, on certain conditions, to contribute liberally to the expenses of the investigation your Committee is carrying on. Briefly stated, these terms are that the trustees of the Museum in question are to have the third set of the specimens collected by Mr. Perkins. Authority to treat with this Museum was given by the Government Grant Committee of the Royal Society, and it is hoped that the British Association will also approve of this course.

The Joint Committee has also decided that the first set of the birds collected by Mr. Perkins shall be placed in the British Museum, and the second set in that of the University of Cambridge.

Since the last report attention has been directed to working out the collections and furnishing detailed accounts thereof. A report on the Orthoptera is daily expected from Herr Hofrath Brunner von Wattenwyl; Lord Walsingham has commenced the examination of the Micro-Lepidoptera, Mr. E. Meyrick that of the larger Lepidoptera. The Mollusca have been entrusted to Mr. E. R. Sykes, who is working at them with the assistance of Mr. E. A. Smith. The Neuroptera have been sent to Mr. R. McLachlan. Mr. Perkins has published a second paper on the Birds; he also, while he was in this country last winter, made considerable progress in working out the Hymenoptera. The Rev. F. O. Pickard Cambridge has looked over the Spiders hitherto received, and estimates them at about 200 species, of which it is probable the majority may prove to be new. The extensive series of Coleoptera is being prepared, at the Cambridge University Museum, for examination.

The Committee is at present in want of funds to maintain Mr. Perkins in the islands until it receives money on account of the proposed agreement with the trustees of the Bernice P. Bishop Museum. It therefore asks for reappointment, with power to avail itself of the assistance of this Museum, and for a grant of 100*l.*

Investigations made at the Laboratory of the Marine Biological Association at Plymouth.—Report of the Committee, consisting of Mr. G. C. BOURNE (*Chairman*), Professor E. RAY LANKESTER (*Secretary*), Professor M. FOSTER, *and* Professor S. H. VINES.

THE Committee were appointed to enable Mr. Edgar J. Allen or other zoologist to investigate the Decapod Crustacea, and Mr. J. J. Lister to work at the Foraminifera at the Laboratory of the Marine Biological Association.

The Committee have received a report from Miss Florence Buchanan, B.Sc., held over from last year on account of ill-health, in addition to Mr. Edgar J. Allen's report, and that of Mr. J. C. Sumner, who occupied the table in January and February 1895.

I. *On a Blood-forming Organ in the Larva of* Magelona. *By* FLORENCE BUCHANAN, *B.Sc.*

In August of 1893 the British Association kindly allowed me the use of their table at Plymouth for the purpose of studying the development of *Magelona.* I was unfortunately prevented from working out the material collected there in time to present my report to the last meeting; and even now what new observations I have to record concern the development of the vascular system only, and I must leave the development of the other organs, or systems of organs, to be described later by myself or some other investigator from a more extended series of stages than I at present possess.

There is a good deal of individual variation with regard to the time of the first appearance of the vascular system, as there is, indeed, with regard to that of other organs also, in the larva of *Magelona.* I have seen a well-developed pulsatile dorsal vesicle, the so-called 'heart,' in larvæ with only eight or nine segments, all bearing provisional chætæ, whilst in other larvæ with a good many more segments there has been no trace of such structure, nor of vascular sytem at all. The 'heart,' which is always the first part of the system to make its appearance, and the dorsal and ventral vessels after it are formed, to begin with, by the accumulation of a transparent fluid between the splanchnic layer of mesoblast and the hypoblast, beginning anteriorly, and thereby causing a pouching of the splanchnic mesoblast in front to form the walls of the 'heart,' which lies mainly in front of the hypoblastic portion of the alimentary canal and over the pharynx, and gradually extending backwards. By the time that the larva has reached the stage in which the body is divided into three regions, and sometimes before the loss of the provisional chætæ of the middle region, there is seen in the living larva at the posterior end of the dorsal vessel, or of what is going to become the dorsal vessel, and in the middle region of the body, a dark reddish-brown mass. This is seen in sections to consist of a much swollen portion of the splanchnic mesoblast in which there are many nuclei, but no distinct cell boundaries, and completely blocking up the space between it and the hypoblast. In later stages, when the splanchnic mesoblast has closed round so as to nip off the dorsal and ventral vessels entirely from the hypoblast, this brown body is no longer to be seen; but floating in the liquid of both dorsal and ventral vessels, and also in the vessels of the tentacles, are pale pink-coloured corpuscles, which in sections are seen to have the appearance of broken-off bits of the dark body present in the earlier stage, and containing for the most part each more than one nucleus. There seems to me to be very little doubt that by the further breaking up of such multinucleate corpuscles the blood-corpuscles of the adult (which were described by Benham at the meeting of the British Association last year) would be formed. I was unfortunately not able to obtain later larval stages and to observe this breaking up going on. But I think my sections of what stages I have justify me in concluding that the peculiar dark body of the middle region of the larva is a corpuscle-forming organ. I do not, however, wish to maintain that *all* the corpuscles of the adult are formed from this larval organ; on the contrary, to judge by sections of the adult, which Dr. Bles kindly lent me to look through whilst I was at Plymouth, I think this is at least a special blood-forming *region* in the dorsal vessel of the adult; but, without having intermediate stages, and a complete series of sections of the adult, I cannot say whether this region corresponds to that in which the larval organ lies. I should like to point out the resemblance which this provisional larval organ bears, both in structure and position, to what I have called the 'vascular ridge' in part of the dorsal vessel of *Hekaterobranchus* ('Q.J.M.S.,' xxxi. pp. 183, 184, pl. xxii. fig. 6). Like other members of the family Spionidæ, *Hekaterobranchus* has no corpuscles in its blood, and the presence of an organ in the dorsal vessel so closely resembling the one in the dorsal vessel of the larval *Magelona* suggests, in the light of the facts I have stated above, either that it at one time *did* have blood-corpuscles formed by a special organ, now persisting only as a vestigial rudiment, or that an organ once having some other significance in both animals has acquired a new significance in the one (*Magelona*).

II. *On the Nervous System of the Embryonic Lobster.* *By* Edgar J. Allen, *B.Sc.*

Whilst occupying a table at the Marine Biological Association's Laboratory during June and July 1894 I was enabled to continue my observations on the nervous system of the embryonic lobster. The observations were carried on, as before, with the aid of methylen-blue.

Additional elements connecting the various ganglia of the thorax with the brain were observed, and their course followed. In the nine ganglia of which the thoracic nerve-chain is really composed, such elements have now been demonstrated in the second (with branches to first and third), the fifth (with branches to fourth and sixth), the eighth (with branches to seventh and ninth), and in the eleventh (with branches to tenth and first abdominal). In this way all the eleven ganglia of the thorax, together with the first abdominal ganglion, are put into direct communication with the brain by means of the four elements whose cells lie in the second, fifth, eighth, and eleventh ganglia.

Of elements belonging to new types which were observed the most interesting were those motor elements which, taking origin in a single cell, gave rise to two or more branches, which passed out of the central nervous system by the nerve-roots of different ganglia. For example, a cell lying in the anterior portion of the lateral mass of ganglion cells in the eighth thoracic ganglion was seen to give off a moderately fine fibre, which divided into two branches, one branch passing immediately out of the ganglion through the anterior nerve-root, whilst the other ran forwards along the ganglionic cord. The forward branch pursued a perfectly straight course until it reached the third thoracic ganglion, where it gave off a branch passing out through the posterior root of the ganglion, and then continued to run forwards to the second thoracic ganglion, passing out through its posterior root. Hence this element, the cell of which lay in the eighth thoracic ganglion, supplied fibres to three nerve-roots belonging to different ganglia, namely, the anterior root of Thorax VIII., the posterior root of Thorax III., and the posterior-root of Thorax II. A number of additional elements were also found in the abdomen. These resemble in a general way those of the thorax, and will be described in detail in a paper which will be published in the 'Quarterly Journal of Microscopical Science.'

III. *On the Echinoderm Fauna of Plymouth. By* J. C. SUMNER.

On receiving the nomination to the British Association Table at Plymouth, I went down in the early part of January with the intention of working at the Echinoderm fauna of the neighbourhood. Unluckily, during the greater part of the time the weather was too bad to permit of any dredging or trawling being done outside the Sound. In consequence the following list is largely compiled from specimens already in the collections at Plymouth. One unnamed specimen in a bottle turned out to be *Amphiura Chiajii*. It was taken two miles S. of the Breakwater, and I believe has not been recorded so far south before.

Crinoidea:

Antedon rosacea	Common.

Ophiuroidea:

Ophiura ciliaris	Common.
Ophiura albida	Rare.
Ophiocnida brachiata	Once taken two miles S. Yealm Head [on sand.
Ophiocoma nigra	Common.
Ophiothrix fragilis	"
Amphiura elegans	"
Amphiura Chiajii	One taken two miles S. Breakwater.

Asteroidea:

Astropecten irregularis	Rare.
Lindia ciliaris	"
Hippasterias phrygiana	Not common.
Porania pulvillus	" "
Asterina gibbosa	Very common.
Palmipes membranacea	Rare.
Solaster papposus	Common.
Henricia sanguinolenta	Rare.
Asterias glacialis	Common.
Asterias rubens	"

Echinoidea:

Echinus acutus	Common.
Echinus miliaris	"
Echinus esculentus	"
Spatangus purpureus	Fairly common.
Echinocardium cordatum	"
Echinocyamus pusillus	Rare.

Holothuroidea:

Cucumaria Hyndmanni	Rare.
Cucumaria pentactes	Common.
Cucumaria lactea	„
Thyone fusus	Rare.
Holothuria nigra	Common.

In conclusion I can only say that I hope to be able to revisit Plymouth before long.

The present state of our knowledge of the Zoology and Botany of the West India Islands, and on taking steps to investigate ascertained deficiencies in the Fauna and Flora.—Eighth Report of the Committee, consisting of Dr. P. L. SCLATER (*Chairman*), Mr. GEORGE MURRAY (*Secretary*), Mr. W. CARRUTHERS, Dr. A. C. L. G. GÜNTHER, Dr. D. SHARP, Mr. F. DUCANE GODMAN, *and* Professor A. NEWTON.

THIS Committee was appointed in 1887, and it has been reappointed each year until the present time.

The Committee have made no fresh collections during the past year, but have continued the work of dealing with those already made; and the following papers have been published, or are complete and ready for publication:—

1. Additional notes on Mr. Elliott's Hepaticæ, by Antony Gepp, M.A. (Journal of Botany).
2. On some small collections of Odonata (Dragonflies) from the West Indies, by W. F. Kirby, F.L.S. (Annals and Magazine of Natural History).
3. On the Longicorn Coleoptera of the West India Islands, by C. J. Gahan, M.A. (Transactions Entomological Society).
4. Report on the Hemiptera of the families Anthocoridæ and Ceratocombidæ, by Professor Uhler (Zoological Society).
5. Report on the Hemiptera Heteroptera of the island of Grenada, by Professor Uhler (Zoological Society).
6. Report on the Hemiptera Homoptera of St. Vincent, by Professor Uhler (Zoological Society).

The examination of the following collections has been undertaken:—

Diatomaceous earths, by Mr. E. Grove.
The Scolytidæ, by Mr. W. F. H. Blandford.
The Diptera of Grenada, by Professor Williston.
The Lepidoptera Heterocera, by Messrs. Butler and Hampson.
The land and fresh-water shells, by Mr. E. A. Smith.
The Elateridæ and Heteromera, by Mr. Champion.
The Phytophaga and Lamellicornia, by Mr. Gahan.
The Buprestidæ, by Captain Kerremans.

The Committee recommend their reappointment, without a grant, to continue the working out of the collections, the following to be members:—Dr. Sclater (Chairman), Dr. Günther, Dr. Sharp, Mr. Godman, Mr. Carruthers, Mr. G. F. Hampson, and Mr. George Murray (Secretary).

Index Generum et Specierum Animalium.—Report of a Committee, consisting of Sir W. H. FLOWER (*Chairman*), Mr. P. L. SCLATER, Dr. H. WOODWARD, *and* Mr. W. L. SCLATER (*Secretary*), *appointed for superintending the Compilation of an Index Generum et Specierum Animalium.*

THE Committee have received from Mr. C. Davies Sherborn the following report of work done since the last meeting of the Association.

Report of Work done from July 1, 1894, *to June* 30, 1895.

Considerable progress has been made in recording during the past year, no less than 480 books and pamphlets having been searched page by page. The chief works dealt with were the French dictionaries of the early part of the century; and when it is mentioned that one of these ('Dictionnaire des Sciences naturelles') runs to sixty volumes of 500 pages each, some idea of the labour expended will be arrived at.

The determination of exact date of publication has been proceeded with, the chief results comprising—

'Sowerby's Recent and Fossil Shells.'
'Shaw's Naturalist's Miscellany.'
'Moore's Lepidoptera Indica.'

Remembering the generous gift of the Association last year, the compiler does not ask for a grant on this occasion, but merely for the reappointment of the Committee.

Migration of Birds.—Report of the Committee, consisting of Professor A. NEWTON (*Chairman*), Mr. JOHN CORDEAUX (*Secretary*), Mr. J. A. HARVIE-BROWN, Mr. WM. EAGLE CLARKE, Mr. R. M. BARRINGTON, *and the* Rev. E. PONSONBY KNUBLEY, *appointed to make a Digest of the Observations on the Migration of Birds at Lighthouses and Light-vessels.*

THE Committee have to report that one of their number, Mr. Wm. Eagle Clarke, has, after very great labour, completed the tabulation, on 2,500 prepared sheets, of the schedules sent in during nine years from the lighthouses and light-vessels on the coasts of Great Britain and Ireland, not a single entry in the original schedules having been omitted. These tabulated sheets have reference to the various birds observed on migration under the separate headings of species, locality, and date.

There now remains the real and most important part of the work—the results arrived at by the nine years' observation—and in order to complete this it is necessary again to consult the vast pile of original schedules with reference to several important headings having connection with meteorological conditions and direction of flight.

Your Committee trust that the final report will be ready for presentation at the next meeting of the Association in 1896, and respectfully ask for their reappointment.

Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Dr. P. L. SCLATER, Professor E. RAY LANKESTER, Professor J. COSSAR EWART, Professor M. FOSTER. Professor S. J. HICKSON, Mr. A. SEDGWICK, *and* Mr. PERCY SLADEN (*Secretary*).

THE Table in the Naples Zoological Station hired by the British Association has been occupied during the past year, under the sanction of your Committee, by Mr. M. D. Hill, who has continued his investigations on the maturation and fecundation of the ova of certain Echinoderms and Tunicates, and has arrived at several interesting and original conclusions, which are briefly sketched out in the appended report of his work which Mr. Hill has furnished.

Your Committee would draw attention to the concluding remarks in Mr. Hill's report respecting the advantages attending the occupation of a table at Naples apart from the exceptional facilities for special and predetermined investigations; and your Committee consider that this furnishes an argument which is alone more than sufficient to justify the continuance of the grant.

Your Committee trust that the General Committee will sanction the payment of the grant of 100*l.*, as in previous years, for the hire of the Table in the Zoological Station at Naples.

The efficiency of the Station in promoting research is now so universally recognised that a recapitulation is unnecessary; and it is an eloquent fact that notwithstanding the rapid multiplication of biological laboratories throughout Europe and America, the number of naturalists who avail themselves of the Naples institution averages between fifty and sixty annually.

Perhaps the most far-reaching move yet undertaken by the Zoological Station consists in the establishment of a small Zoological Station on New Britain (also known as Neu Pommern), an island adjacent to New Guinea. Mr. Parkinson, a planter, who had lived there for some years, recently called upon Dr. Dohrn in Naples, and expressed his willingness to erect a small building on his estate suitable for a laboratory, if the Naples Station would provide all the necessary apparatus. This generous offer was accepted, and the requisite equipment was duly despatched from Germany and Naples last September.

At the same time Mr. Arthur Willey, whose name is well known for his work on Tunicates and *Amphioxus*, and who has previously occupied the British Association Table, announced his intention of going to New Britain for the purpose of studying the anatomy and embryology of *Nautilus pompilius*, and kindly offered to assist in the erection and management of the new laboratory.

Dr. Dohrn laid great stress on the necessity of instructing native fishermen for the service of the new Station in order to save European naturalists as much as possible all bodily exertion connected with their scientific pursuits, and to enable them to concentrate full energy on their mental work. With this object in view Mr. Parkinson has sent two young Papuans to Naples, and they are now being instructed by Signor Salvatore Lobianco in the various and well-known arts of the Zoological Station. From the latest accounts received from Naples this novel experiment of transforming two Papuans into biological fishermen offers every prospect of success.

This new Colonial Station will remain under the control of the Naples Station, and Dr. Dohrn hopes soon to make known such regulations and conditions as may enable competent naturalists to work there profitably and successfully.

The progress of the various publications undertaken by the Station is summarised as follows :—

1. Of the 'Fauna und Flora des Golfes von Neapel,' the monograph by Dr. W. Müller on 'Ostracoda' (404 pp., 40 plates), has been published. Monographs by Dr. Bürger on 'Nemertinea' and by Dr. Jatta on 'Cephalopoda' are in the press.

2. Of the 'Mittheilungen aus der Zoologischen Station zu Neapel,' vol. xi., parts iii. and iv., with 11 plates, have been published.

3. Of the 'Zoologischer Jahresbericht,' the whole 'Bericht' for 1893 has been published.

4. A new and thoroughly revised German edition of the 'Guide to the Aquarium' has been published.

The details extracted from the general report of the Zoological Station, which have been courteously furnished by the officers, will be found at the end of this report. They embrace lists (1) of the naturalists who have occupied tables since the last report, and (2) of the works published during 1894 by naturalists who have worked at the Zoological Station.

The preserved specimens sent out by the station during the year ending June 1895 comprised 180 consignments, amounting to about 14,900 fr., as against 194 consignments amounting to 17,687·70 fr. in the preceding year.

I. *Report on the Occupation of the Table. By* Mr. M. D. Hill.

I occupied the Table of the British Association from October 1, 1894, to February 20, 1895.

I investigated the maturation and fecundation of the ova of certain Echinoderms and Tunicates in order to clear up, if possible, certain debated points, more especially as regards the origin and behaviour of the centrosome. When I began to work, Fol's account of the 'Quadrille des Centres' had been accepted unchallenged, and so gratifying were his results from a theoretical standpoint, that several text-books had reproduced his figures as being true representations of what actually occurs. Since sending in an account of my work to await publication, two memoirs [1] have appeared dealing with the same subject. The authors have arrived at practically the same results, and as they all agree very closely, it is unnecessary to recapitulate mine at any length. It will be sufficient to state that according to all three accounts there is nothing resembling a 'quadrille'; the centrosomes and astrospheres owe their origin to the 'body' of the spermatozoon; and there is no trace of an egg-centre or egg astrosphere. In the finer details, however, our accounts differ somewhat, and I venture to think that Messrs. Wilson & Matthews have entirely, and Professor Boveri partly, overlooked the true centrosome. The two former authors describe the astrosphere as containing no centrosome proper, but in its place a network closely resembling an ordinary nuclear reticulum. This condition is maintained throughout. Boveri, on the other hand, finds a minute deeply-staining centrosome shortly after the sperm head has penetrated into the ovum. In the later stages this centrosome swells up into a large hollow vesicle. I agree with Boveri in his first statement, but believe that later on he has missed the true centrosome, and has figured and described as a vesicle the 'heller Hof,' for I find at this stage a deeply-staining sharply-defined centrosome in the midst of a clear 'heller Hof.' My attention was chiefly confined to *Sphaerechinus granularis*, and it may be, though it seems highly improbable, that a different process may take place in different species.

In the tunicates *Phallusia mamillata* and *Ciona intestinalis* I found much the same relations as in the Echinoderms as regards the origin and behaviour of the centrosome, and for this investigation the Ascidian ovum proved a very favourable object to study. I have been able to trace carefully the maturation and fertilisation in *Phallusia*, and have coupled my results in one paper with those I obtained from studying the Echinoderms. I was also able, though with rather less certainty, to make out the number and mode of division of the chromosomes during maturation. The nucleus of the ovocyte I. (to use Boveri's well-known nomenclature) contains eight chromosomes. From their subsequent behaviour I see no reason to suppose that they form two 'Vierer Gruppen,' but look upon them as of equal independent value. The eight chromosomes divide by transverse division into sixteen for each polar body, eight therefore remaining in the nucleus of the ovum (female pro-nucleus). There is therefore, here at any rate, no 'reducing' or 'equalling' division. Owing to the very small size and close approximation together of the chromosomes, this part of the work was attended with considerable difficulty.

The sperm head breaks up into eight chromosomes, and the first segmentation spindle therefore contains sixteen, the normal number for the species.

It would be out of place to discuss here the bearing these results may have on points of general cytology, or on those theories of heredity which have been based on observations of like phenomena in other forms, above all, in *Ascaris megalocephala*.

Before closing this report, however, I should like to emphasise once more the great advantages which an occupation of a Table at the Naples

[1] *Boveri*, 'Ueber das Verhalten der Centrosomen bei der Befruchtung des Seeigel-Eies,' *Verhandl. des Phys.-med. Gesell. zu Würzburg*, Bd. xxix., 1895. *Wilson and Matthews*, 'Maturation, Fertilization, and Polarity in the Echinoderm Egg.' *Journ. of Morphol.*, vol. x., No. 1.

Station has for a student of zoology, and especially for one who like myself had just finished his University course. Although original research is doubtless the main object of most who go to Naples, still it is impossible to over-estimate the value of the knowledge gained by seeing and becoming acquainted with the rich fauna of the bay. Personally speaking, to observe alive so many forms only seen before in drawings, or at most as preserved specimens, has been a source of keen enjoyment. Further, the intercourse with men of other nationalities, and of other ideas and methods, cannot but have a beneficial effect on those who stay for any length of time. For these privileges my sincere thanks are due to the Committee of the British Association.

II. *A List of Naturalists who have worked at the Zoological Station from the end of June* 1894 *to the end of June* 1895.

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
804	Prof J. Ogneff	Russia	July 1, 1894	Aug. 19, 1894
805	Dr. G. Mazzarelli	Italy	Aug. 1, „	—
806	Stud. V. Diamare	„	„ 1, „	—
807	Prof. F. S. Monticelli	„	„ 1, „	Nov. 17, „
808	Prof. D'Abundo	„	„ 3, „	Sept. 5, „
809	Dr. N. León	Rumania	„ 7, „	Oct. 28, „
810	Prof. Della Valle	Italy	„ 11, „	„ 18, „
811	Mag. J. Lebedinsky	Russia	„ 17, „	Feb. 6, 1895
812	Dr. Colorni	Italian Navy	„ 23, „	Oct. 1, 1894
813	Dr. A. Sandias	Italy	Sept. 8, „	Sept. 23, „
814	Prof. W. E. Ritter	Harvard College	„ 19, „	Dec. 29, „
815	Prof. E. Drechsel	Switzerland	„ 20, „	Oct. 18, „
816	Prof. B. Grassi	Italy	„ 24, „	Nov. 2, „
817	Dr. H. Driesch	Hamburg	„ 26, „	May 21, „
818	Dr. C. Herbst	Prussia	„ 26, „	„ 21, „
819	Mr. M. D. Hill	British Association	„ 29, „	Feb. 19, 1895
820	Prof. J. Gardiner	Davis Table	Oct. 1, „	Mar. 1, „
821	Dr. T. H. Morgan	Smithsonian Institution	„ 29, „	—
822	Prof. Herbert Osborn	„ „	Dec. 15, „	„ 7, „
823	Ten. A. Acton	Italian Navy	„ 17, „	—
824	Dr. H. v. Bloedau	Prussia	„ 27, „	Feb. 7, „
825	Prof. S. Trinchese	Italy	Jan. 1, 1895	—
826	Dr. A. Russo	„	„ 1, „	—
827	Dr. G. Jatta	Zoological Station	„ 1, „	—
828	Cand. G. Tagliani	Italy	„ 1, „	—
829	Dr. R. Schneider	Prussia	„ 1, „	Apr. 8, 1895
830	Dr. S. Orlandi	Italy	„ 3, „	—
831	Dr. O. vom Rath	Baden	„ 7, „	June 6, „
832	Dr. W. Karawaieff	Russia	„ 23, „	Mar. 3, „
833	Sr. F. Massa	Italy	„ 26, „	—
834	Dr. A. Zohrt	Russian Navy	Feb. 1, „	June 30, „
835	Dr. L. Neumayer	Bavaria	„ 20, „	Apr. 13, „
836	Dr. R. Krause	Prussia	„ 23, „	„ 9, „
837	Sig. P. Romano	Italy	Mar. 1, „	—
838	Dr. M. Laurie	Cambridge	„ 2, „	June 9, „
839	Dr. F. Reinke	Prussia	„ 7, „	Apr. 11, „
840	Dr. R. Hesse	Würtemberg	„ 9, „	„ 10, „
841	Baron J. Uexküll	Strasburg	„ 10, „	—
842	Dr. J. Sobotta	Prussia	„ 10, „	—
843	Dr. V. Haecker	Würtemberg	„ 13, „	„ 23, „

II. A LIST OF NATURALISTS—*continued.*

Number on List	Naturalist's Name	State or University whose Table was made use of	Duration of Occupancy	
			Arrival	Departure
844	Prof. E. Worschelt	Prussia	Mar. 13, 1895	Apr. 24, 1895
845	Dr. H. Rabl	Austria	„ 15, „	„ 16, „
846	Dr. A. Spuler	Baden	„ 21, „	„ 24, „
847	Prof. v. Lenhossék	Hesse	„ 27, „	„ 16, „
848	Dr. O. Van der Stricht	Belgium	Apr. 1, „	June 8, „
849	Prof. J. Reighard	Harvard College	„ 2, „	„ 3, „
850	Dr. O. Seydel	Holland	„ 8, „	—
851	Prof. J. F. Heymans	Belgium	„ 18, „	May 12, „
852	Dr. P. Ziegenhagen	Prussia	„ 20, „	—
853	Prof. G. v. Koch	Hesse	May 3, „	—
854	Dr. N. Iwanzoff	Russia	„ 13, „	—
855	Dr. G. Valenza	Italy	„ 29, „	—
856	Prof. C. Nutting	Harvard College	June 4, „	—

III. *A List of Papers which were published in the year* 1894 *by the Naturalists who have occupied Tables in the Zoological Station.*

H. Pollard . . . Observations on the Development of the Head in Gobius capito. 'Quart. J. Micr. Sc.,' vol. 35, 1894.

O. Maas . . . . Die Embryonolentwickelung u. Metamorphose der Cornacuspongien. 'Zool. Jahrb.,' Abth. Anat. u. Ontog., Bd. 7, 1894.

E. Mac Bride . . . The Organogeny of Asterina gibbosa. 'Proc. R. Soc.,' vol. 54, 1894.

P. Klemm . . . Ueber die Regenerationsvorgänge bei den Siphonaceen. Ein Beitrag zur Erkenntniss der Mechanik der Protoplasmabewegungen. 'Flora, oder Allg. bot. Zeitg.,' Heft 1, 1894.

W. Weldon . . . On Certain Correlated Variations in Carcinus mænas. 'Proc. R. Soc.,' vol. 54, 1894.

A. Russo . . . Contribuzione alla genesi degli organi negli Stelleridi. 'Atti R. Accad. Sc. fis. e mat.,' vol. 7, 1894.

„ Studii anatomici sulla famiglia Ophrotrichidæ del Golfo di Napoli. 'Ricerche Lab. Anat. norm.,' Roma, vol. 4, 1894.

„ Sull' apparecchio genitale del Syndesmis echinorum. 'Boll. Soc. Nat. Napoli,' vol. 8, 1894.

Ph. Knoll . . . Ueber die Blutkörperchen bei wirbellosen Thieren. 'Sitz. Ber. Akad. Wiss. Wien,' Math. Nat. Cl., B. 102, 1893!

T. Groom . . . On the Early Development of Cirripedia. 'Phil. Trans. Roy. Soc.,' London, vol. 185, 1894.

J. v. Uexküll . . . Physiologische Untersuchungen an Eledone moschata. III. Fortpflanzungsgeschwindigkeit der Erregung in den Nerven. 'Zeitschr. f. Biologie,' B. 30, 1894.

„ Physiologische Untersuchungen an Eledone moschata. IV. Zur Analyse der Functionen des Centralnervensystems. *Ibid.*, B. 31, 1894.

H. C. Bumpus . . . The Median Eye of Adult Crustacea. 'Zool. Anz.,' Jgg. 17, 1894.

W. Wheeler . . . Protandric Hermaphroditism in Myzostoma. *Ibid.*

V. Willem . . . La structure des palpons d'Apolemia uvaria, Fsch., et les phénomènes de l'absorption dans ces organes. 'Bull. Acad. R. Belgique,' t. 27, 1894.

W. Nagel . . . Beobachtungen über den Lichtsinn augenloser Muscheln. 'Biol. Centralblatt,' B. 14, 1894.

" Vergleichend physiologische und anatomische Untersuchungen über den Geruchs- und Geschmackssinn u. ihre Organe. 'Bibl. Z.,' Heft 18, 1894.

" Experimentelle sinnesphysiologische Untersuchungen an Coelenteraten. 'Arch. Phys. Pflüger,' B. 57, 1894.

" Ein Beitrag zur Kenntniss des Lichtsinnes augenloser Thiere. 'Biol. Centralblatt,' B. 14, 1894.

O. Lanz . . . . Zur Schilddrüsenfrage. Leipzig, 1894 (*partim*).

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The Climatology of Africa.—Fourth Report of a Committee, consisting of Mr. E. G. RAVENSTEIN (*Chairman*), Mr. BALDWIN LATHAM, Mr. G. J. SYMONS, Mr. H. N. DICKSON, *and* Dr. H. R. MILL (*Secretary*). (*Drawn up by the Chairman.*)

YOUR Committee in the course of last year granted a complete set of instruments, including a mercurial barometer presented to them by the Meteorological Council, to the Scottish missionaries established at Kibwezi, on the road from Mombasa to Machako's. They also supplied Mr. Hobley, now in Uganda, with one of Symons's earth thermometers.

Sets of instruments have now been supplied to the following stations :—

Bolobo (Rev. R. Glennie).—Registers up to date have been regularly received since January 1891. The abstract for the past year has been prepared by Mr. H. N. Dickson.

Lauderdale, Nyasaland (Mr. J. W. Moir).—An abstract of one year's observations has been sent home through Mr. Scott Elliott.

Zombe, Nyasaland (Mr. J. Buchanan).—Registers of the observations made from June 1892 to March 1894 have been received. The abstract published in the Appendix has been prepared by Mr. Dickson.

Lambarene, Ogowe (Rev. C. Bonzon).—Only one month's observations have been received.

Kibwezi, British East Africa (Scottish Mission).—The instruments were only granted this year. One year's rainfall observations have been received.

Warri, Benin (Capt. Gallwey).—The registers have been received up to the date. An abstract has been prepared by Mr. Dickson.

The sets at all these stations, with the exception of Warri, include a mercurial barometer, four thermometers, and a rain-gauge. That at Warri includes a black bulb thermometer.

Meteorological reports from thirteen stations in British East Africa have been received. These stations lie on or near the coast, between Wasin and the Jub, and along the road connecting Mombasa with Fort Smith in Kikuyu, the climate of which is described as being exceptionally well suited to European residents. These observations were, in most instances, made by officials of the Imperial British East Africa Company. The abstracts have been prepared by the Chairman. (See Map, p. 491.)

Your Committee regret that the instructions laid down for the guidance of observers should, in many instances, have been set aside, and that observations should have been made at hours precluding the possibility of deducing trustworthy means. Where circumstances do not admit of the instruments being read thrice daily—at 7 A.M., 2 P.M., and 9 P.M.—the thermometers should be read at 9 A.M., or twice daily, at an interval of twelve hours. The barometers, however, should be read at intervals of six hours—say at 9 A.M. and at 3 P.M.

Your Committee have expended the 5*l.* granted. They beg to propose that they be reappointed, and that a grant be made of 10*l.*, which would enable them to establish a station near Lake Ngami.

Zomba. Lat. 15° 23′ *S., Long.* 35° 20′ *E.*, 3,130 *feet.*

Months	8 A.M.					Noon					4 P.M.					Rain			Wind—Days								
	Atmospheric Pressure	Temp. Dry	Temp. Wet	Vapour Pressure	Relative Humidity	Atmospheric Pressure	Temp. Dry	Temp. Wet	Vapour Pressure	Relative Humidity	Atmospheric Pressure	Temp. Dry	Temp. Wet	Vapour Pressure	Relative Humidity	Amount	Days	Heaviest Fall	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm
1892	In.	°	°	In.	p.c.	In.	°	°	In.	p.c.	In.	°	°	In.	p.c.	In.		In.									
June	26·880	62·1	60·0	0·492	88	26·882	68·7	64·3	0·548	79	23·877	68·3	64·3	0·554	80	0·00	0	0·00	3	10	0	3	0	2	2	1	9
July	26·898	60·1	58·1	0·460	89	26·899	66·5	62·0	0·501	77	26·898	66·3	62·1	0·506	79	0·45	2	0·33	0	16	0	9	0	1	0	4	0
August	26·844	62·8	58·4	0·436	76	26·855	71·4	62·1	0·444	58	26·841	70·9	62·6	0·466	62	0·45	1	0·45	0	7	0	15	0	3	0	1	2
September	26·890	67·9	64·7	0·572	84	26·880	76·2	70·0	0·656	73	26·830	75·7	69·4	0·641	72	0·10	1	0·10	0	7	3	19	0	0	0	0	1
October	26·806	72·4	68·5	0·649	81	26·804	79·8	70·5	0·631	62	26·802	79·5	71·0	0·654	65	0·84	4	0·35	0	14	5	7	4	0	0	1	0
November	26·783	71·8	66·2	0·576	74	26·782	81·1	71·1	0·639	60	26·778	80·6	71·7	0·667	64	8·82	12	2·23	0	4	4	11	6	0	0	2	3
December	26·726	69·9	67·5	0·642	88	26·720	74·1	68·1	0·613	73	26·716	74·8	68·7	0·627	73	12·36	16	3·58	1	0	0	15	7	3	0	0	5
1893																											
January	23·662	71·2	68·0	0·646	84	26·665	75·9	70·0	0·660	74	26·653	76·0	70·2	0·667	74	6·90	15	1·16	0	10	2	15	0	3	0	1	0
February	26·703	69·7	66·9	0·627	86	26·709	75·6	70·3	0·676	76	26·703	75·6	70·1	0·668	75	9·33	11	1·20	0	1	1	14	5	5	0	1	1
March	26·760	69·3	67·7	0·659	92	26·763	73·8	69·2	0·658	79	26·760	73·5	69·3	0·665	81	6·55	10	1·77	—	—	—	—	—	—	—	—	—
April	—	—	—	—	—	26·880	70·0	64·3	0·532	73	—	—	—	—	—	2·54	10	0·70	—	—	—	—	—	—	—	—	—
May	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·22	1	0·22	—	—	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·12	1	0·12	—	—	—	—	—	—	—	—	—
July	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1·09	7	0·46	—	—	—	—	—	—	—	—	—
August	26·909	62·5	58·7	0·449	80	26·907	68·6	60·8	0·437	63	26·885	69·0	61·7	0·460	65	0·00	0	0·00	—	—	—	—	—	—	—	—	—
September	26·797	68·7	64·5	0·555	79	26·788	75·5	64·4	0·470	53	26·782	74·4	63·9	0·466	55	0·60	2	0·55	—	—	—	—	—	—	—	—	—
October	26·792	69·7	63·4	0·506	70	26·787	79·3	65·6	0·468	47	26·763	77·5	65·4	0·482	51	0·20	4	0·10	—	—	—	—	—	—	—	—	—
November	26·766	71·2	66·4	0·590	77	26·763	84·8	68·1	0·487	41	26·766	83·2	67·4	0·483	42	1·95	1	1·95	—	—	—	—	—	—	—	—	—
December	26·751	72·7	68·6	0·649	81	26·749	79·3	69·5	0·603	60	26·742	79·2	69·4	0·599	60	8·56	16	1·42	—	—	—	—	—	—	—	—	—
1894																											
January	26·716	70·7	68·0	0·651	87	26·712	77·4	70·7	0·668	71	26·697	76·8	70·4	0·665	72	9·87	21	2·52	—	—	—	—	—	—	—	—	—
February	26·711	71·2	67·5	0·628	83	26·715	77·3	70·6	0·666	71	26·711	76·3	70·3	0·665	73	18·86	24	2·04	—	—	—	—	—	—	—	—	—
March	26·745	68·8	65·8	0·598	85	26·742	74·9	68·9	0·633	73	26·739	73·0	67·9	0·621	77	13·00	20	2·21	—	—	—	—	—	—	—	—	—

The readings of the barometer were reduced to 32° F. by the observer. A further correction for gravity, amounting to −0·068 in., has been applied in accordance with the formula $p=p'(1-0·0026\cos 2\phi)(1-0·0000003h)$. The pressure of vapour and relative humidity have been deduced from the readings of the wet and dry bulbs by means of *Guyot's Tables* (4th ed., p. 82), with corrections as for mean barometric pressure of 27·0 in.

Lauderdale (Chipokas). Lat. 16° 2′ *S., Long.* 35° 36′ *E.,* 2,340 *feet. Observer: John W. Moir.*

1893–94	Mean Temperature						Temperature Extremes		Mean Temperature. Wet Bulb			Relative Humidity			Rain			Cloud (1-10)		
	6 A.M.	Noon	6 P.M.	Max.	Min.	Monthly Mean	Highest	Lowest	6 A.M.	Noon	6 P.M.	6 A.M.	Noon	6 P.M.	Amount	Days	Heaviest Fall	6 A.M.	Noon	6 P.M.
1893	°	°	°	°	°	°	°	°	°	°	°	°	°	°	In.		In.	°	°	°
July	54·2	68·9	61·0	73·0	[58·0]	61·6	—	—	53·7	63·7	59·7	97	74	90	7·17	15	3·75	—	—	—
August	60·4	75·6	68·5	79·4	60·3	67·1	85·0	51·0	58·4	68·3	64·3	88	67	78	0·19	3	0·18	—	—	—
September	66·5	82·1	74·4	85·8	64·4	72·8	91·5	51·0	61·8	69·8	65·8	75	53	61	0·41	2	0·36	—	—	—
October	68·0	81·3	76·4	84·6	66·3	73·8	93·5	60·0	64·2	68·1	68·1	80	48	63	1·58	7	0·76	—	—	—
November	71·5	85·4	73·9	90·3	68·9	77·7	94·8	61·0	67·2	73·2	69·3	79	53	56	2·26	9	1·45	2·45	5·33	4·00
December	70·7	80·9	75·7	87·2	68·6	75·5	95·0	63·5	68·8	74·7	71·4	90	74	80	8·50	26	1·65	7·28	6·97	7·68
1894																				
January	69·2	77·0	74·3	81·2	67·3	73·0	83·3	64·2	67·6	73·6	71·6	92	72	87	15·83	28	2·16	7·06	8·20	7·71
February	69·4	78·3	74·3	81·7	68·1	73·4	85·8	64·2	69·0	74·7	72·2	97	84	90	13·43	26	2·15	6·69	7·22	7·64
March	68·3	73·2	72·9	78·7	66·6	71·6	83·8	63·5	67·8	73·0	71·2	97	85	91	12·31	28	2·00	8·00	7·50	8·00
April	64·4	73·0	69·6	75·6	63·0	68·1	84·9	58·5	63·3	69·4	67·8	94	82	89	11·61	25	3·63	5·04	7·36	7·16
May	60·6	69·9	66·3	73·3	59·4	64·9	81·2	54·0	59·6	66·0	63·8	94	80	87	3·00	18	1·56	4·30	6·70	4·97
June	57·7	68·3	63·1	71·2	56·1	62·0	75·1	52·1	55·3	62·1	59·8	85	68	81	0·67	12	0·32	3·60	6·60	5·70
Year	65·1	76·4	71·4	80·2	64·0	70·2	96·0	51·0	63·1	69·7	67·0	89	70	78	76·96	199	3·63	—	—	—

The plantation of Lauderdale lies 11 miles to the S.S.W. of the main peaks of Milanje. At Fort Anderson, 10 miles to the S.E. of it, the rainfall from July 1893 to March 1894 amounted to 54·52 in., whilst during the same period it reached 61·68 in. at Lauderdale.

Mean temperature assumed = ¼ (6+6+max.+min.).

Mombasa. Lat. 4° 4′ *S., Long.* 39° 42′ *E.,* 60 *feet. Observer: J. J. W. Pigott.*

1894	Pressure of Atmosphere		Temp. Extremes		Mean Temperature							Daily Range	Variableness	Mean Temp. Wet Bulb				Relative Humidity				Rain		
	10 A.M.	4 P.M.			7.30	10	1	4	Max.	Min.	Monthly Mean			7.30	10	1	4	7.30	10	1	4	Amnt.	Days	Heaviest Fall
	In.	In.	°	°	°	°	°	°	°	°	°	°	°	°	°	°	°	p.c.	p.c.	p.c.	p.c.	In.		In.
January	29·802	29·682	85·0	76·0	80·1	82·2	83·1	83·1	83·5	77·5	80·5	6·0	0·7	77·3	76·7	77·1	77·6	85	77	75	77	0·16	2	0·12
February	29·815	29·693	86·0	77·0	81·3	82·2	83·3	82·9	83·6	78·0	80·8	5·6	0·5	77·3	76·0	76·4	76·7	87	74	71	74	2·51	3	2·14
March	29·814	29·680	86·0	77·1	81·9	83·4	83·6	83·4	85·1	78·7	81·9	6·4	0·6	77·9	77·1	77·1	77·1	83	74	73	73	1·46	6	0·46
April	29·839	29·730	89·7	75·0	80·7	82·5	83·4	82·6	82·1	75·7	80·4	3·4	1·1	76·6	76·4	76·8	76·6	82	75	72	75	3·04	8	1·63
May	29·887	29·794	86·8	72·3	77·9	79·0	79·4	78·9	82·2	76·0	79·1	6·2	1·2	74·6	74·6	74·5	74·4	85	80	78	80	12·29	18	3·62
June	29·934	29·889	81·9	72·0	75·7	76·6	76·0	76·4	80·3	73·4	76·8	6·9	0·9	73·3	72·2	71·9	71·1	88	80	81	78	4·27	11	1·63
July	29·982	29·892	82·2	71·5	75·4	76·5	77·5	77·2	80·4	73·4	76·9	7·0	0·8	72·4	71·8	71·7	72·0	86	78	74	76	1·49	7	0·50
August	29·971	29·879	83·8	71·5	75·8	77·4	77·7	77·2	80·8	73·7	77·2	7·1	0·8	72·3	72·2	72·0	72·0	84	76	74	76	1·33	9	0·40
September	29·957	29·850	82·9	71·8	77·3	78·5	78·9	78·3	81·6	74·9	78·2	6·7	0·4	73·5	73·0	72·6	72·6	83	76	73	75	0·29	8	0·70
October	29·836	29·783	84·1	75·0	79·5	80·5	80·2	79·8	82·8	77·0	79·9	5·8	0·6	75·2	74·8	74·6	74·4	81	75	76	76	0·65	9	0·27
	9 A.M.					9 A.M.									9 A.M.				9 A.M.					
November	29·851	—	86·0	74·1	—	80·8	—	—	83·6	77·8	80·7	5·8	0·6	—	76·3	—	—	—	80	—	—	7·59	19	1·18
December	29·825	—	84·1	74·0	—	80·5	—	—	83·0	76·6	79·8	6·4	0·6	—	75·6	—	—	—	78	—	—	2·88	2	1·53
Year	—	—	89·7	71·5	—	—	—	—	82·4	76·3	79·3	6·1	0·7	—	—	—	—	—	—	—	—	37·96	102	3·62

Atmospheric pressure reduced to 32° F. and corrected for gravity. In 1893 the results, for 10 A.M., were 0·006 in. higher; for 4 P.M. 0·026 in. higher. The pressure in both years was greatest in August.

Mean temperature assumed = ½ (max. + min.). Means for 1893 and 1894: year, 79° F.; Jan. 80°·1, March 82°, July 76°·6; mean daily range: 6°·4 F. (April 5°·2, June 7°·2).

Variableness (mean difference in the daily means from day to day): mean, 0°·7 F.; mean of the extremes in each month, 2°·5 F. The observations recorded by Mr. Pigott inspire confidence. Instrumental errors, however, are not known.

Chuyu. Lat. 4° 30′ *S., Long.* 39° 21′ *E. Observers: K. MacDougall and R. C. Fobo.*

1894	Pressure of Atmosphere.		Mean Temperature					Rain		
	10 A.M.	4 P.M.	7.30 A.M.	10 A.M.	1 P.M.	4 P.M.	Approx. Monthly Mean	Amount	Days	Heaviest Fall
	In.	In.	°	°	°	°	°	In.		In.
January .	29·804	29·710	80·4	83·1	83·7	83·2	82·0	—	—	—
February .	·844	·715	81·7	83·6	85·3	84·2	83·5	2·05	3	1·61
March .	·818	·726	79·5	84·4	83·5	82·6	81·5	2·12	7	0·93
April .	·895	·779	79·3	80·9	81·3	81·6	80·3	2·63	6	1·50
May . .	·936	·833	76·4	78·7	77·7	78·1	77·0	10·81	17	2·58
June. .	30·049	·932	74·4	75·9	76·3	76·4	75·3	5·54	19	1·43
July. .	·034	·945	73·7	75·0	75·6	75·7	74·7	4·19	11	1·30
August .	·016	·916	74·3	75·4	75·7	75·8	75·0	2·05	3	1·17
September	29·996	·878	75·6	77·9	77·6	77·8	76·6	0·16	1	0·16
October .	·933	·821	78·0	79·8	79·9	79·9	78·9	0·11	2	0·09
November	·899	·834	78·7	80·4	81·3	80·8	80·0	7·42	15	1·43
December.	9 A.M. 29·881	—	9 A.M. 80·6	—	—	—	80·6	4·94	7	1·62
Year .	—	—	—	—	—	—	78·8	42·02	91	2·58

Chuyu lies on the mainland, opposite Wasin Island.

Pressure of atmosphere reduced to 32° F. and corrected for gravity. Temperature: The mean assumed = ½(7·30+1). Extremes recorded during the year: 71° and 87°·5 F. Rainfall: No entries for January; perhaps no rain fell.

Malindi. Lat. 3° 13′ *S., Long.* 40° 7′ *E. Observers: D. Macquarie, J. Bell Smith, and K. MacDougall.*

1894	Mean Temperature					Rain		
	7.30	10	1	4	Approx. Monthly Mean	Amount	Days	Greatest Fall
January .	80·1	81·7	82·2	81·8	81·1	0·40	2	0·35
February .	80·1	81·4	81·8	81·5	80·9	0·05	1	0·05
March .	82·0	84·0	84·2	83·8	83·1	1·28	3	0·85
April .	84·0	85·3	85·8	84·8	84·9	0·45	3	0·20
May . .	78·2	81·4	77·7	80·7	77·9	14·09	14	3·25
June. .	81·2	82·3	82·1	81·3	81·2	5·21	18	1·30
July . .	77·9	78·6	78·8	78·4	78·3	1·76	8	0·44
August .	77·8	79·1	79·1	78·3	78·4	1·18	10	0·19
September	78·8	80·6	80·6	79·8	79·7	0·00	0	0·00
October .	81·0	82·3	82·1	81·8	81·5	0·07	1	0·07
November	81·5	81·1	82·0	81·5	81·7	2·50	1	2·50
December .	—	9 A.M. 80·5	—	—	80·5	1·96	6	0·95
Year 1894	80·2	81·5	81·4	81·4	81·1	28·95	67	2·25
Year 1893	79·0	80·9	81·3	80·6	80·1	50·79	109	2·85

Mean Temperature assumed = ½(7·30+1). Annual range only 7° F., daily range almost non-existent.

Magarini (Malindi Plantations), 3° 5′ S., 40° 6′ E., about 8 miles N.W. of Malindi. Observer: James Weaver.

1894–95	Temperature: Extremes		Mean Temperature			Daily Range	Rain		
	Max.	Min.	Max.	Min.	Monthly Mean		Amount	Days	Heaviest Fall
1894									
March	93	70	91·4	71·2	81·3	20·2	3·38	4	1·78
April	94	70	91·8	72·6	82·2	19·2	0·65	4	0·38
May	92	67	88·1	70·2	79·1	17·9	10·31	15	2·67
June	89	63	83·3	67·7	75·5	15·6	4·42	13	0·87
July	91	63	86·2	65·7	75·9	20·5	1·69	13	0·45
August	91	65	87·6	66·0	76·8	21·6	0·72	?	?
September	90	64	89·5	65·5	77·5	24·0	0·07	3	0·40
October	94	62	89·3	67·4	78·3	21·9	0·00	0	—
November	91	71	89·3	71·7	80·5	17·6	7·56	11	3·67
December	91	67	89·2	71·2	80·2	18·0	4·48	6	2·56
1895									
January	93	67	91·3	70·3	80·8	21·0	0·00	0	0·00
February	93	68	91·4	69·8	80·6	21·6	0·11	1	0·11
Year	94	62	89·0	69·1	79·1	19·9	33·39	[75]	3·67

Temperature quite untrustworthy. The daily range, to judge from observations made in 1892, does not appear to exceed 12°, whilst the mean temperature is about 73° F.

The rains only commenced on March 7, about 24 to 30 days behind the normal period, and it was then too late for sowing rice and mtama, *except on irrigated and*,

Lamu, 2° 16′ S., 40° 54′ E. Observer: Donald MacLennan.

1894	Mean Temperature				Relative Humidity		Rain		
	Dry Bulb		Wet Bulb						
	10 A.M.	4 P.M.	10 A.M.	4 P.M.	10 A.M.	4 P.M.	Amount	Days	Heaviest Fall
					p.c.	p.c.	In.		
January	85·4	82·9	75·4	73·9	60	66	0	0	—
February	85·0	83·1	75·3	74·8	64	65	0	0	—
March	84·2	81·7	76·0	74·3	67	69	0·15	1	0·15
April	84·3	82·5	77·1	75·3	70	70	0·25	1	0·25
May	81·7	79·1	76·2	75·3	77	83	15·28	16	3·00
June	79·5	76·8	74·7	73·0	79	83	2·15	7	0·75
July	80·2	79·2	75·5	73·8	79	76	0·45	3	0·30
August	79·7	79·0	74·6	74·0	78	78	0·22	2	0 12
September	81·0	80·5	76·5	75·8	80	80	0	0	—
October	83·1	81·9	77·7	77·1	77	79	0·10	1	0·10
November	82·7	82·0	77·4	76·5	78	77	1·60	2	1·40
	9 A.M.		9 A.M.		9 A.M.				
December	83·1	—	77·6	—	77	—	0·94	4	0·35
Year	—	—	—	—	—	—	21·14	37	3·00

Kisimayu, 0° 22′ S., 42° 33′ E. Observer: C. H. Crauford.

1894–95	Mean Temperature	Rain		
		Amount	Days	Heaviest Fall
1894	°	In.		In.
April	84·0	3·89	3	2·10
May	81·0	5·24	10	1·40
June	79·0	1·17	2	0·70
July	79·0	0·53	3	0·35
August	79·0	0·52	2	0·45
September	79·1	0·00	0	—
October	81·5	0·29	1	0·29
November	80·3	0·60	4	0·40
December	81·5	1·59	2	1·33
1895				
January	81·0	0·00	0	—
February	82·0	0·00	0	—
March	84·0	0·00	0	—
Year	79·5	13·73	27	2·10

The 'mean' temperature here given appears to be the mean of 10 A.M. and 4 P.M., and the true mean does not consequently exceed 77°.

Machako's (Ukamba). ***Lat.* 1° 31′ *S., Long.* 37° 18′ *E.,* 5,400 *feet. Observer: John Ainsworth.***

1894	Mean Temperature					Variableness	Mean Temp. Wet Bulb				Relative Humidity				Rain		
	7.30	10	1	4	Approx. Monthly Mean		7.30	10	1	4	7.30	10	1	4	Amount	Days	Heaviest Fall
											p.c.	p.c.	p.c.	p.c.			
January	60·9	69·7	74·2	72·1	67·5	0·4	57·2	60·2	62·2	61·1	78	55	47	50	0·75	3	0·50
February	63·0	72·0	77·4	74·7	70·2	1·5	59·4	62·1	63·9	61·5	80	54	44	43	0·16	2	0·12
March	63·6	71·6	73·0	73·8	68·3	2·0	60·6	63·3	64·8	63·2	83	61	62	52	5·48	11	1·76
April	62·8	68·2	72·9	71·7	67·3	1·0	60·2	62·9	64·2	62·8	85	73	60	58	9·33	12	1·94
May	61·1	65·7	69·1	68·3	65·1	1·3	58·9	61·1	62·8	62·3	87	75	69	70	1·93	8	0·53
June	57·6	61·8	65·2	64·1	61·4	1·0	55·5	57·7	59·5	58·7	87	77	70	71	0·58	3	0·47
July	56·3	62·5	68·1	67·2	62·2	1·5	54·1	56·6	58·8	57·9	86	67	54	54	0·09	3	0·05
August	58·2	64·8	69·2	67·5	63·7	1·4	54·7	57·5	58·9	57·6	79	62	51	51	0·06	2	0·03
September	59·6	67·9	73·6	71·4	66·6	1·6	56·3	59·4	61·3	59·7	80	57	45	43	0·02	1	0·02
October	62·6	71·0	75·8	73·0	69·2	1·2	58·9	61·2	62·4	60·3	79	54	43	43	1·27	6	0·70
November	62·2	67·7	70·7	68·3	66·4	1·5	59·8	62·5	63·8	62·7	86	73	67	72	18·16	22	3·18
December	62·4	67·0	69·9	69·0	66·1	2·1	59·0	61·6	63·4	62·6	81	72	68	67	4·13	11	1·25
Year	60·9	67·5	71·6	70·1	66·2	1·4	57·9	60·5	62·2	60·9	82	65	56	56	41·97	84	3·18

MACHAKO'S.

Mean Temperature assumed = ½(7·30 + 1). Annual range 8°·8, daily range perhaps 15°.

Variableness: mean 1°·4; mean of the extremes in each month 3°·7.

Rainfall.—The rainfall in November was quite exceptional; the natives do not remember such a heavy fall for the time of the year. In 1893 only 6·64 in. fell.

Fort Smith (Kikuyu). ***Lat.* 1° 14′ *S, Long.* 36° 44′ *E,* 6,400 *feet. Observers: F. G. Hall and J. M. De Winton (September).***

1894	Mean Temperature					Variableness	Mean Temp. Wet Bulb				Relative Humidity				Rain			Prevail. Wind
	7.30	10	1	4	Approx. Monthly Mean		7.30	10	1	4	7.30	10	1	4	Amount	Days	Heaviest Fall	
											p.c.	p.c.	p.c.	p.c.	in.		in.	
January	58·7	66·9	72·2	63·3	65·4	1·7	55·4	59·0	62·9	62·0	80	60	57	90	1·12	3	0·72	N.E.
February	59·5	68·5	76·0	72·5	67·7	1·1	56·2	60·0	63·0	62·6	80	58	45	55	0·23	2	0·20	N.E.
March	60·3	69·0	72·3	68·5	66·3	1·9	58·2	61·3	62·6	60·8	89	62	55	62	5·33	12	2·96	N.E.
April	58·6	64·2	70·4	66·7	64·5	1·2	57·2	61·0	65·8	62·4	90	77	77	77	7·23	20	1·40	N.E.
May	57·5	63·5	67·2	64·7	62·3	1·9	57·0	62·0	65·7	63·8	97	91	92	95	8·11	22	2·07	E.
June	55·6	60·0	64·0	62·8	59·8	1·6	55·0	58·4	62·8	62·0	96	90	93	93	3·46	13	1·38	N.E.
July	53·2	60·2	65·3	64·3	59·2	1·5	52·5	59·2	63·5	62·9	97	94	88	91	2·13	8	1·08	N.E.
August	54·2	59·2	65·9	62·6	60·1	1·9	53·4	58·9	64·1	61·2	92	98	88	91	1·02	9	0·37	—
September	54·8	61·1	70·2	65·5	63·0	1·5	54·1	59·9	68·8	64·4	95	99	93	94	2·22	10	1·08	—
October	56·1	62·9	71·1	65·6	63·6	1·5	55·4	61·4	68·9	63·6	96	91	88	89	1·27	11	0·53	—
November	56·0	61·5	66·6	65·5	61·3	1·5	55·4	60·0	65·4	64·5	96	91	93	94	6·68	c. 24	2·13	E.N.E.
December	56·3	62·1	68·7	63·5	62·5	1·3	55·0	59·7	64·1	60·7	91	86	76	82	9·32	16	1·67	—
Year	56·7	63·3	69·2	65·5	62·9	1·6	55·4	60·1	64·8	62·5	92	83	78	84	48·12	150	2·96	—

FORT SMITH.

Mean Temperature assumed = ½(7·30 + 1). Annual range 8°·5; daily range perhaps 15°.

Variableness: mean 1°·6; mean of the extremes in each month 4°·3.

Rainfall.—The rainfall in December seems to have been exceptionally heavy. In 1893 only 3·80 in. fell. On the other hand the 'great rains' in March and April were very light, for only 12·56 in. fell, as compared with 29·25 in. in 1893.

British East Africa. Rainfall—Amount in Inches.

Station	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Chuyu (4° 38 S., 39° 21 E.).	1893	4·51	1·53	6·74	*15·30*	10·80	9·24	2·65	2·01	0·32	0·68	*10·94*	1·55	66·27
	1894	—	2·05	2·12	2·63	*10·81*	5·54	4·19	2·05	0·16	0·11	*7·42*	4·94	—
	1895	—	0·25	2·00	—	—	—	—	—	—	—	—	—	—
Mombasa (4° 4′ S., 39° 42′ E., 60 ft.).	1875	—	—	—	12·20	*14·13*	6·30	9·22	1·89	0·35	4·60	0·35	*4·68*	—
	1876	0·35	0·18	3·57	5·99	*16·40*	3·16	4·68	2·72	2·68	1·00	0·56	0·60	41·89
	1890	—	—	—	6·94	*16·65*	1·59	2·10	1·36	0·57	0·15	2·52	1·32	—
	1891	0·62	0·02	0·62	3·74	*14·81*	5·63	1·68	2·03	2·46	*8·83*	3·53	2·56	46·56
	1892	0·11	0·43	0·41	6·18	*11·32*	1·43	2·17	1·26	1·52	0·35	1·26	0·39	26·83
	1893	2·43	1·85	4·68	12·51	*14·29*	7·69	2·15	2·78	2·10	2·27	*10·91*	0·51	64·17
	1894	0·16	2·51	1·46	3·04	*12·29*	4·27	1·49	1·33	0·29	0·65	*7·59*	2·88	37·96
	1895	0·01	0·34	3·03	—	—	—	—	—	—	—	—	—	—
	Mean[1]	1·22	0·94	2·16	7·67	*13·47*	4·63	3·72	2·78	2·55	3·50	*5·51*	1·73	49·88
Takaungu (3° 41′ S., 39° 52′ E.). Observers in 1894: J. Bell Smith and K. MacDougall.	1892	0·82	0·26	—	1·14	*14·01*	5·21	1·53	1·21	2·70	0·00	*2·71*	0·00	—
	1893	1·50	0·57	5·41	7·01	*9·39*	7·87	2·80	1·67	0·55	1·39	*1·86*	0·64	40·66
	1894	0·00	0·00	1·91	4·57	*15·39*	5·46	1·85	0·49	0·37	0·17	*7·20*	0·60	38·01
	1895	0·00	0·08	5·11	—	—	—	—	—	—	—	—	—	—
	Mean	0·58	0·23	4·14	4·24	12·93	6·18	2·06	1·12	1·21	0·52	3·92	0·41	37·54
Malindi (3° 13′ S. 40° 7′ E.).	1891	—	—	—	5·85	*12·00*	4·26	3·68	2·08	1·80	3·31	3·48	*4·02*	—
	1892	0·61	0·50	0·49	5·97	*14·90*	3·94	1·82	0·29	1·41	0·35	0·15	0·19	30·12
	1893	0·75	0·12	2·38	*18·50*	7·83	7·65	2·26	1·71	1·05	1·14	*5·77*	1·63	50·79
	1894	0·40	0·05	1·28	0·45	*14·09*	5·21	1·76	1·18	0·00	0·07	*2·50*	1·96	28·95
	1895	0·03	0·10	0·85	—	—	—	—	—	—	—	—	—	—
	Mean	0·45	0·19	1·25	7·69	*12·08*	5·26	2·38	1·31	1·07	1·22	*2·97*	1·95	37·82
Jilore (3° 10′ S., 39° 55′ E.).	1893	3·75	2·24	2·96	*6·77*	4·92	3·62	1·14	2·04	0·69	0·59	*4·71*	—	—
	1894	—	—	1·87	—	—	—	—	—	—	—	*4·49*	3·69	—
	1895	0·10	—	2·58	—	—	—	—	—	—	—	—	—	—
Magarini (3° 5′ S., 40° 6′ E.).	1893	0·85	0·37	2·69	*13·45*	5·25	5·61	2·65	1·97	0·72	0·84	*4·80*	1·00	40·20
	1894	0·00	0·00	3·38	0·65	*10·31*	4·42	1·69	0·72	0·07	0·00	*7·56*	4·48	33·28
	1895	0·00	0·11	3·97	—	—	—	—	—	—	—	—	—	—
Lamu (2° 16′ S., 40° 54′ E.).	1890	0·21	0·00	1·50	1·95	*18·06*	2·50	2·17	1·22	1·20	0·13	0·04	0·00	28·98
	1893	0·41	1·04	2·97	15·50	*16·35*	2·93	0·85	0·56	0·97	*1·70*	0·35	0·91	44·54
	1894	0·00	0·00	0·15	0·25	*15·28*	2·15	0·45	0·22	0·00	0·10	*1·60*	0·94	21·14
	Mean	0·20	0·35	1·54	5·90	16·56	2·53	1·16	0·66	0·72	0·64	0·66	0·62	31·55
Kisimayu (0° 22′ S., 42° 33′ E.).	1893	—	—	—	4·49	*5·63*	0·16	0·00	—	—	—	—	—	—
	1894	—	—	—	3·89	*5·24*	1·17	0·53	0·52	0·00	0·29	0·60	*1·59*	13·73
	1895	0·00	0·00	0·00	—	—	—	—	—	—	—	—	—	—
Mbungu (3° 46′ S., 39° 30′ E.). Observer: Rev. — Hofmann.	1891	—	—	—	—	6·03	2·25	0·85	1·12	1·21	0·70	*3·72*	3·54	—
	1892	1·52	1·49	2·37	1·76	2·69	1·53	—	—	—	—	—	1·56	—
	1893	4·47	1·13	*8·65*	5·84	3·78	—	0·49	2·13	0·51	1·56	*5·07*	—	—
	1894	—	—	—	—	7·30	0·64	1·70	0·75	0·03	0·04	5·64	2·08	—
	1895	0·00	1·09	4·17	—	—	—	—	—	—	—	—	—	—
Ndi (3° 20′ S., 38° 29′ E., 2,400 ft.). Observer: Ch. Wise.	1894	—	—	—	—	—	—	—	—	—	—	2·40	5·69	—
	1895	1·10	2·22	5·01	—	—	—	—	—	—	—	—	—	—
Kibwezi (2° 25′ S., 37° 55′ E., 3,000 ft.): Observer: Rev. T. Watson.	1893	—	—	—	—	—	—	—	—	—	—	*15·72*	7·80	—
	1894	0·12	0·58	*6·64*	1·44	1·13	0·05	0·00	0·00	0·00	0·00	*13·55*	3·24	26·73
Machako's (1° 31′ S., 37° 18′ E., 5,400 ft.).	1893	—	—	—	—	—	—	—	—	0·00	1·37	6·64	6·34	—
	1894	0·75	0·16	5·48	*9·33*	1·93	0·58	0·09	0·06	0·02	1·27	*18·16*	4·13	41·96
	1895	0·00	3·85	10·13	—	—	—	—	—	—	—	—	—	—
Fort Smith, Kikuyu (1° 14′ S., 36° 44′ E., 6,400 ft.).	1893	—	—	13·65	*15·60*	8·54	0·28	1·01	—	2·63	0·61	*5·09*	3·80	—
	1894	1·12	0·23	5·33	7·23	*8·11*	3·46	2·13	1·02	2·22	1·27	6·68	*9·32*	48·12
	1895	0·00	7·43	10·46	—	—	—	—	—	—	—	—	—	—

[1] The means for Mombasa are deduced from nearly eleven years' observations, including those made at Frere Town, where 90·06 in. fell in 1877, 51·30 in. in 1875, 45·57 in. in 1879, and 44·75 in. in 1880.

Heaviest Fall of Rain within 24 Hours.

Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Chuyu	—	1·61	0·93	1·50	*2·58*	1·43	1·30	1·17	0·16	0·09	1·43	1·62
Mombasa	0·12	2·14	0·46	1·63	*3·62*	1·63	0·50	0·40	0·70	0·27	1·18	1·53
Takaungu	—	—	1·41	1·87	*4·55*	1·70	0·75	0·15	0·19	0·17	0·38	0·33
Malindi	0·35	0·05	0·85	0·20	*3·25*	1·30	0·44	0·19	—	0·07	2·50	0·95
Jilore	—	—	1·12	—	—	—	—	—	—	—	1·20	2·16
Magarini	—	—	1·78	0·38	2·67	0·87	0·45	—	0·40	—	*3·67*	2·56
Lamu	0·00	0·00	0·15	0·25	*3·0*	0·75	0·30	0·12	—	0·10	1·40	0·35
Kisimayu	—	—	—	2·10	*1·40*	0·70	0·35	0·45	0·00	0·29	0·40	1·3
Mbungu	—	—	—	—	*1·68*	0·22	0·76	0·19	0·03	0·04	1·57	0·92
Kibwezi	0·12	0·33	2·90	1·04	0·67	0·05	—	—	—	—	*3·34*	1·18
Machako's	0·50	0·12	1·76	1·94	0·53	0·47	0·05	0·03	0·02	0·70	*3·18*	1·25
Fort Smith	0·72	0·20	*2·96*	1·40	2·07	1·38	1·08	0·37	1·08	0·53	2·13	1·67

Number of Rainy Days.

Only Days on which at least 0·01 in. of Rain fell are counted.

Station	Year	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Chuyu	1893	5	2	5	10	19	20	16	12	4	2	17	4	116
"	1894	—	3	7	6	17	19	11	3	1	2	15	7	—
"	1895	—	1	9	—	—	—	—	—	—	—	—	—	—
Mombasa	1893	7	8	10	19	24	16	14	22	13	10	15	6	164
"	1894	2	3	6	8	18	11	7	9	8	9	19	2	102
"	1895	1	3	7	—	—	—	—	—	—	—	—	—	—
Takaungu	1893	3	1	7	12	21	18	11	11	4	3	10	1	102
"	1894	—	—	3	4	14	14	8	4	3	1	9	3	—
"	1895	0	2	8	—	—	—	—	—	—	—	—	—	—
Malindi	1893	3	1	5	22	18	14	12	9	5	6	10	4	99
"	1894	2	1	3	3	14	18	8	10	—	1	1	6	—
"	1895	3	1	2	—	—	—	—	—	—	—	—	—	—
Jilore	1893	4	6	8	6	13	15	9	14	6	3	10	[3]	[97]
"	1894	—	—	4	—	—	—	—	—	—	—	7	5	—
"	1895	6	—	7	—	—	—	—	—	—	—	—	—	—
Magarini	1893	5	1	4	21	22	24	18	17	9	2	21	6	150
"	1894	—	—	4	4	15	13	13	—	3	0	11	6	—
"	1895	0	1	9	—	—	—	—	—	—	—	—	—	—
Lamu	1893	3	1	8	22	24	9	4	4	4	3	2	2	86
"	1894	0	0	1	1	16	7	3	2	0	1	2	4	37
Kisimayu	1893	—	—	—	12	11	2	0	—	—	—	—	—	—
"	1894	—	—	—	3	10	2	3	2	0	1	4	2	2
"	1895	0	0	0	—	—	—	—	—	—	—	—	—	
Mbungu	1893	9	3	12	9	10	—	4	11	3	5	15	—	—
"	1894	—	—	—	—	14	11	5	10	1	1	14	8	—
Ndi	1894	—	—	—	—	—	—	—	—	—	—	5	11	—
"	1895	2	2	10	—	—	—	—	—	—	—	—	—	—
Kibwezi	1894	1	2	6	4	3	1	0	0	0	0	17	10	44
Machako's	1893	—	—	—	—	—	—	1	1	0	6	21	25	—
"	1894	3	2	11	12	8	3	3	2	1	6	22	11	84
Fort Smith	1893	—	—	16	25	16	2	3	—	4	8	18	19	—
"	1894	3	2	12	20	22	13	8	9	10	11	[24]	16	150

Bolobo (Congo). Lat. 2° 10′ S., Long. 16° 13′ E., 1,100 feet.
Observer: Rev. Robert Glennie, Baptist Missionary Society.

Month	Pressure of Atmosphere: Means				Temp.: Extremes		Mean Temperature (Shade)						Daily Range
	7 A.M.	2 P.M.	9 P.M.	Mean	Min.	Max.	7 A.M.	2 P.M.	9 P.M.	Max.	Min.	Mean	
1894					°	°	°	°	°	°	°	°	°
January .	28·807	28·698	28·755	28·753	65·2	91·0	73·5	83·7	75·3	85·9	70·6	77·0	15·3
February .	28·793	28·709	28·746	28·749	66·7	95·0	74·1	85·0	76·2	87·6	71·0	77·9	16·6
March . .	28·815	28·739	28·771	28·775	68·0	95·7	74·1	87·0	76·4	88·5	71·7	78·5	16·8
April . .	28·820	28·739	28·780	28·780	68·8	94·5	74·3	85·7	75·5	88·4	71·7	77·8	16·7
May . . .	28·804	28·737	28·790	28·777	68·0	94·0	73·9	84·8	76·4	87·5	71·5	77·9	16·0
June . .	28·875	28·798	28·842	28·838	69·0	92·7	72·6	85·1	76 1	87·2	71·3	77·5	15·9
July . .	28·901	28·815	28·867	28·861	68·0	91·1	71·9	85·0	75·6	86·8	70·6	77·0	16·0
August .	—	28·782 ?	28·821 ?	—	(66·0)	—	72·5	83·8	77·7	—	70·3	77·9	—
September	(28·864)[1]	(28·763)	(28·824)	(28·817)	(68·8)	(92·4)	74·2	85·9	76·5	88·0	72·2	78·3	15·8
October .	—	—	—	—	(67·4)	(89·2)	73·4	81·8	73·9	85·8	70·9	75·7	14·9
November	—	—	—	—	67·0	92·1	73·7	82·4	74·5	85·4	70·6	76·3	14·8
December .	—	—	—	—	65·4	91·6	73·7	83·8	75·7	86·3	70·8	77·2	15·5
Year .	—	—	—	—	65·2	—	73·5	84·5	75·8	—	71·1	77·4	—

[1] 14th to 30th only.

BOLOBO (CONGO)—*continued.*

Month	Mean Temp. Wet Bulb			Force of Vapour			Relative Humidity			Cloud—Amount				Rain			Weather		
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Mean	Amount	Days	Heaviest Fall	Thunder	Lightning	Strong Wind
1894	°	°	°	In.	In.	In.	p.c.	p.c.	p.c.	°	°	°	°	In.		In.			
January .	71·9	76·2	72·7	·760	·802	·769	92	70	88	8·4	5·8	6·7	7·0	6·64	12	2·10	4	0	2
February .	72·5	77·2	73·2	·776	·828	·777	92	69	86	7·8	6·0	6·1	6·6	10·59	11	6·44	2	1	2
March . .	72·4	77·4	73·2	·772	·810	·774	92	63	85	8·2	6·5	6·0	6·9	3·75	10	2·38	3	1	0
April . .	72·6	76·9	72·6	·777	·805	·762	92	65	86	7·7	6·4	6·1	6·7	7·67	11	5·00	4	0	3
May . . .	72·3	77·1	73·5	·771	·826	·787	92	69	86	7·8	6·8	6·0	6·9	6·71	13	2·83	3	1	2
June . .	70·0	76·0	72·3	·698	·774	·741	87	64	82	7·9	6·5	6·3	6·9	0.00	0	0·00	0	0	1
July . .	68·4	74·3	71·7	·647	·702	·724	83	58	82	7·2	8·2	7·6	7·7	0·03	1	0·03	0	0	1
August .	(69·5)	—	—	(·680)	—	—	(85)	—	—	(8·6)	—	(6·8)	—	3·85	7	1·00	1	0	1
September	70·4	75·2	72·2	·692	·729	·732	82	59	80	(7·1)	(6·1)	(7·8)	(7·0)	2·69?	5?	1·28 ?	3	0	0
October .	71·4	74·8	71·3	·741	·767	·732	90	71	88	8·6	6·9	5·4	7·0	4·31	9	0·64	0	0	0
November	72·0	75·3	72·1	·761	·781	·755	92	71	88	8·2	6·7	7·5	7·5	5·46	13	1·20	2	0	2
December .	71·8	76·0	73·0	·754	·792	·775	91	68	87	8·7	5·4	5·2	6·4	11·03	13	4·47	1	2	1
Year . .	71·3	—	—	·737	—	—	89	—	—	8·0	—	6·5	—	62·73	105	6·44	23	5	15

In the hourly barometric observations considerable interruption, through illness of the observer and other causes, was unavoidable. The observations wanting on the term days during the first four months of 1895 have been interpolated as far as possible by drawing the curve for each day and filling up by comparison with the curves for days immediately preceding and following it. It must be admitted that the method is liable to considerable error, but under the circumstances it is believed that the results may be useful.

The barometer readings have in all cases been reduced to 32° F. and corrected for gravity.

Bolobo Hourly Barometer Observations, 1894.

Hour	January			February		
	1st	11th	21st	1st	11th	21st
Midnight	28·802	28·897	28·*878*	28·808	28·*832*	28·851
1 A.M.	·798	·*895*	·*876*	·824	·*838*	·835
2 „	·*797*	·*894*	·873	·840	·*844*	·*835*
3 „	·797	·*893*	·865	·*840*	·*850*	·835
4 „	·*795*	·*891*	·*870*	·839	·*857*	·*845*
5 „	·791	·890	·*876*	·*847*	·*865*	·*864*
6 „	·836	·920	·881	·*860*	·*872*	·890
7 „	·877	·938	·887	·871	·879	·919
8 „	·884	·939	·901	·875	·886	·925
9 „	·893	·947	·912	·*878*	·910	·952
10 „	·883	·934	·901	·880	·926	·947
11 „	·871	·914	·883	·864	·922	·937
Noon	·821	·908	·872	·834	·891	·906
1 P.M.	·805	·878	·850	·810	·848	·858
2 „	·770	·856	·824	·771	·825	·830
3 „	·755	·849	·786	·743	·807	·817
4 „	·745	·858	·778	·726	·786	·791
5 „	·742	·855	·780	·715	·772	·777
6 „	·753	·855	·786	·722	·776	·782
7 „	·783	·866	·791	·*740*	·801	·785
8 „	·813	·880	·819	·*763*	·813	·813
9 „	·831	·911	·843	·781	·842	·829
10 „	·837	·913	·857	·821	·*860*	·851
11 „	·837	·*914*	·866	·825	·*865*	·863

Hour	March			April		
	1st	11th	21st	1st	11th	21st
Midnight	28·920	28·*890*	28·764	—	—	—
1 A.M.	·*880*	·*896*	·*767*	—	—	—
2 „	·*858*	·899	·*770*	—	—	—
3 „	·854	·*898*	·*773*	—	—	—
4 „	·857	·898	·*779*	—	—	—
5 „	·889	·*905*	·*785*	—	—	—
6 „	·*910*	·*921*	·*793*	28·853	28·*852*	28·866
7 „	·925	·936	·808	·865	·858	·886
8 „	·939	·946	·834	·866	·870	·903
9 „	·937	·947	·856	·882	·886	·920
10 „	·935	·946	·851	·872	·*885*	·917
11 „	·906	·*933*	·844	·845	·873	·889
Noon	·883	·911	·817	·832	·844	·871
1 P.M.	·862	·886	·781	·799	·816	·850
2 „	·840	·860	·749	·779	·804	·810
3 „	·807	·860	·690	·739	·*790*	·777
4 „	·795	·860	·707	·726	·*748*	·763
5 „	·791	·858	·725	·724	·*740*	·753
6 „	·807	·*859*	·720	·*746*	·*766*	·783
7 „	·816	·867	·749	·788	·*818*	·818
8 „	·831	·873	·793	·817	·830	·852
9 „	·861	·876	·826	·856	·826	·859
10 „	·888	·887	·834	·860	·*823*	·875
11 „	·902	·*894*	·*838*	·860	·*821*	·891

Warri (Benin). Lat. 5° 31′ N., Long. 5° 51′ E., 10 feet. Observers: Felix Roth, M.R.C.S., M.L.C.P., and B. H. Elliott, M.B.

Month	Temperature					Temp.: Extremes		Daily Range	Black Bulb	Rain			Direction of the Wind: Number of Days in which it blew from a specified direction — 7 A.M.									6 P.M.								
	Mean 7 A.M.	Mean 6 P.M.	Max.	Min.	Mean	Highest	Lowest			Amount	Days	Heaviest Fall	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm
1894	°	°	°	°	°	°	°	°	°	In.		In.																		
January . .	72·2	81·4	93·1	70·5	81·8	96	62	22·6	149·7	0·23	3	0·20	8	4	2	0	0	2	13	2	0	2	0	3	1	0	1	17	7	0
February. .	74·5	82·5	95·9	73·0	84·4	102	69	22·9	153·8	3·03	3	2·78	5	0	2	3	2	2	12	2	0	1	0	1	2	1	5	18	0	0
March . . .	75·3	80·4	93·6	72·5	83·0	98	68	21·1	156·1	5·55	17	1·03	0	4	4	6	5	3	8	1	0	0	0	2	1	0	7	19	2	0
April . . .	76·4	80·0	94·1	72·7	83·4	99	69	21·4	158·3	6·35	14	1·15	3	3	4	5	3	5	6	1	0	2	2	1	2	1	5	15	2	0
May . . .	74·8	79·7	92·4	72·0	82·2	99	69	20·4	154·7	22·86	24	5·36	1	3	3	7	3	8	3	3	0	2	1	0	0	2	18	6	2	0
June . . .	74·3	78·5	88·5	71·9	80·2	95	69	16·6	145·8	16·41	24	3·95	0	2	0	4	2	21	1	0	0	0	0	0	0	1	27	1	1	0
July . . .	73·0	78·3	88·4	71·6	80·0	94	67	16·8	153·7	6·74	14	2·00	0	0	0	0	1	12	18	0	0	0	0	0	0	1	7	23	0	0
August . .	72·7	77·7	87·7	70·4	79·0	92	67	17·3	148·9	12·27	18	4·79	0	0	0	0	3	6	22	0	0	0	0	0	0	0	8	23	0	0
September .	74·5	76·9	87·1	71·7	79·4	94	67	15·4	150·1	13·07	21	1·70	0	0	0	0	1	22	7	0	0	0	0	0	0	2	23	5	0	0
October . .	73·4	73·5	89·7	71·0	80·3	96	68	18·7	157·3	13·54	15	4·19	2	1	2	2	1	19	3	1	0	0	0	0	1	4	19	6	1	0
November .	74·3	79·3	93·2	72·3	82·7	99	69	20·9	167·0	5·63	10	1·25	1	1	2	0	1	21	0	4	0	0	0	0	0	2	28	0	0	0
December .	73·1	81·4	93·3	71·2	82·2	99	70	22·1	153·0	6·24	8	3·16	4	2	2	0	1	19	2	1	0	0	0	0	0	0	31	0	0	0
Year . . .	74·1	79·1	91·4	71·7	81·5	102	62	19·7	154·0	111·92	171	5·36	24	20	21	27	23	140	95	15	0	7	3	7	7	14	179	133	15	0
1895																														
January . .	73·1	81·8	93·1	71·4	82·2	97	66	21·7	146·8	2·12	4	2·38	2	1	5	0	2	21	0	0	0	1	0	0	1	0	29	0	0	0
February .	74·0	82·9	95·6	71·9	83·7	99	69	23·7	140·1	0·05	2	0·03	2	1	1	2	5	17	0	0	0	0	0	0	0	0	25	3	0	0
March. . .	74·9	81·1	95·0	70·9	83·0	98	63	24·1	141·1	8·87	14	1·71	2	2	3	7	2	15	0	0	0	0	0	1	2	0	27	0	1	0
April . . .	75·5	81·8	94·8	71·7	83·2	99	65	23·1	141·9	5·44	14	1·11	2	1	4	5	1	12	5	0	0	0	1	0	0	4	20	5	0	0

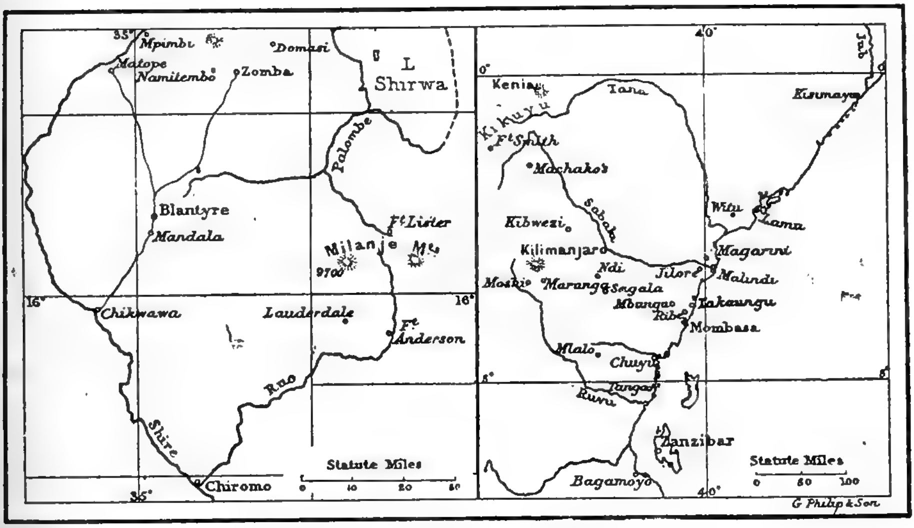
The readings of the minimum and maximum thermometers are not to be trusted. The mean temperature does not probably exceed 76° F., instead of being 81° F., as deduced from the mean maxima and minima.

Lambarene, Ogowe, Lat. 0°·40′ *S., Long.* 10°·18′ *E.* *Observer : Rev. C. Bonzon.*

Result of observations made at 9 A.M. during November 1893.

Barometer at 32°	29·864 in.
Temperature : mean of maxima .	87°·9 F.
,, ,, minima .	70°·2
Extremes . . .	93° 0 and 66°·3
Dry bulb . . .	77°·5
Wet bulb . . .	75°·0

Rain, 13·10 in. on 23 days. Heaviest fall, 1·64 in. Cloud, amount, 8·0.



Meteorological Stations in East Africa.

The Exploration of Southern Arabia.—Report of the Committee, consisting of Mr. H. SEEBOHM (*Chairman*), Mr. J. THEODORE BENT (*Secretary*), Mr. E. G. RAVENSTEIN, Dr. J. G. GARSON, *and* Mr. G. W. BLOXAM. (*Drawn up by* Mr. BENT.)

THIS last winter, after leaving Muscat we proceeded along the coast for a distance of 640 miles, and applied ourselves to the exploration of a certain district known as Dhofar, with the Gara mountains. The results of this expedition, which lasted over several weeks, may be treated of under three different heads :—

1. The geographical results referring to the nature of the country, its configuration, and its productions.
2. The anthropological results, with an account of the inhabitants and a comparison of them with those of other parts of Arabia.
3. The archæological results of the study of the various ruins and identification of sites mentioned by ancient authors.

(1) The district of Dhofar is for Arabia a most remarkable one. It constitutes a sort of oasis by the sea, and consists of a flat alluvial plain about 60 miles long and 9 miles at its widest point, very fertile, and with

abundance of water lying either in stagnant pools or procurable by sinking shallow wells. It is capable of producing almost anything: cocoanut palms grow in clusters along its whole length; cotton, indigo, tobacco, plantains, jowari; and in the gardens papyas, mulberries, lemons, oranges, and chillis grow profusely. The inhabitants of the villages scattered along the coast are for Arabia particularly prosperous; they are governed by a representative from the Sultan of Oman, who has of late years been successful in establishing peace. Behind this rich plain is a range of mountains, known as the Gara range, rising to about 3,000 feet above the sea level. In the valleys sloping towards the Indian Ocean on the south, and towards the desert of Nejd on the north, are found the various frankincense districts where the frankincense tree, *Boswellia Carteri*, is still found, and which constitutes an industry for the inhabitants, as it has done for thousands of years. There are three chief districts where the shrub grows, and the export of the gum is now about 9,000 cwt. per annum, which is sent to Bombay in dhows. Myrrh is also found in proximity to the frankincense tree, and in ancient days the commerce in these odoriferous drugs gained for this district a world-wide reputation.

The Gara hills are rounded and undulating, except on the coast side, where the approach is precipitous and rugged; they are of limestone formation, and retain a surprising amount of moisture, which is at the same time the cause of their fertility and the fertility of the plain of Dhofar, which is an alluvial deposit from them. The valleys running into these hills from the coast are of great fertility, containing a dense mass of tropical vegetation, huge sycamores block up the valley, with cacti, acacias, and numerous creepers; in several places lodgments of water have formed themselves into little lakes or tarns, an altogether unknown condition of affairs in any other part of Arabia. The mountain sides are honeycombed with caves, in which the inhabitants dwell with their flocks and herds. Right up to the summits of the Gara mountains the same condition of fertility is observable—they are covered with grass all over, and clusters of sycamores grow right up at the summit, giving to them quite a parklike appearance; and the flora of this district is very extensive. Although we were there during the dry season we collected 260 different specimens of plants, as against 150 collected during a much longer period and more extended area in the Hadramut last year. These plants have now been deposited at Kew, and though more numerous they do not contain so many new varieties as those from the Hadramut; they establish an extension westwards of the Indian and Beloochistan flora, whereas those of the Hadramut are more African in their character, tending to prove by their geographical distribution that the floral line of demarcation between Asia and Africa takes place somewhere between the Hadramut and Dhofar.

From the summit of the Gara range an interesting view over the frankincense country is obtained. To the north the hills slope down towards the desert of Nejd, which gradually destroys the vegetation, and ends in a long blue horizon like the sea. To the east and west the same characteristics are observable, and to the south the view is bounded by the sea. The district of Dhofar owes its peculiar fertility to the water-retaining qualities of its geological composition, and to the regularity of its rainfalls, which occur from July to September, when the valleys are turned into torrents, and even the Bedouins find it difficult to get about.

On proceeding up a valley to the east of the Gara range we came across a very curious natural phenomenon. The valley, which is here about a mile and a half broad, with hills on either side reaching an elevation of about 2,000 feet, has been blocked up by a calcareous deposit, which has collected round an isolated hill in the centre of the valley, and has formed itself into a perfectly sheer and precipitous wall or abyss. To the east of this hill the abyss is 550 feet high and three-quarters of a mile in length. It is hung with white stalactites, and presents a whitish-grey colour; over this abyss small waterfalls precipitate themselves, and the ground below is spongy and fertile, and all along the river bed the rocks are white with calcareous deposit. At the top of this abyss an exceedingly fertile flat meadow extends for several miles inland, richly wooded, and providing rich pasturage for the cattle of the Bedouins, who own it; and about a mile and a half from the abyss are two lakes joined together by a meandering stream. They are long and narrow, but in places of considerable depth, and it is the overflow from these lakes which falls over the abyss. Bulrushes, water plants, and water birds abound here, and the spot is marvellously fertile.

(2) The inhabitants of the Dhofar district may be divided into two distinct groups, namely, the Arab inhabitants of the coast villages who cultivate the fertile plain, and occupy themselves in fishing, and the nomad Bedouins of the Gara tribe, who inhabit the mountains, and are purely pastoral.

The coast Arabs are chiefly from Oman, and are of the Ibadiyeh sect, recognising the Sultan of Oman as the head of the church. This sect of Mohammedans is much less fanatical than the others in Arabia, probably from the long struggle they had with the Wahabis of Nejd at the commencement of this century. They offered no objection to our visiting their mosques, and we were subjected whilst amongst them to none of that fanatical hatred which caused us so much inconvenience during our sojourn in the Hadramut last year. The mosques of the Ibadiyeh are small and without minarets; their heterodoxy consists in not accepting any of the Imams who succeeded Mohammed, but they consider that the Imam or head of the church is to be elected by the people as occasion requires.

Eighteen years ago the Arabs in Dhofar were in a very sorry condition, and sent to the Sultan of Oman to ask him for a governor: the blood feuds between the tribes and the hostile attitude of the Bedouins rendering existence almost intolerable. Sultan Tourki of Oman sent as Wali a trusted friend of his named Suleiman, who has been there nearly ever since. and by his wise rule and administrative power peace and a measure of prosperity have been restored amongst the Gara tribe. The Arabs themselves never penetrate into the interior, but are content to cultivate the fertile plain of Dhofar, and inhabit the prosperous villages by the coast.

The Bedouins of the Gara tribe, who are perhaps the wildest and most uncivilised of any of the tribes of the South of Arabia, form a most interesting study for the anthropologist. They are clearly an aboriginal race, as distinct from the Arab as the Spaniard is from the American Indian. They are small of stature and of limb, but exceedingly lithe and well made. They go about naked, save for a loin cloth, and wear their long tangled locks bound together by a leather thong. There are hardly any firearms amongst them, but every man carries with him three indispensable weapons—his shield made of wood or sharkskin, with a knob at one end, which he turns round when tired, and uses as a stool; his flat iron sword with a wooden handle; and his throw stick, a wooden weapon pointed at both ends, which he uses with great skill both in war and in the chase.

The Gara live chiefly, as stated above, in the deep caves of their limestone mountains, which provide accommodation for the family and many head of cattle. They have a large number of milch cows and goats, and make ghee in great quantities, which is exported from here. All their implements are of the most primitive description. The churn is a skin hung on three sticks which a woman shakes about until butter is formed; to make their cows give milk freely they stretch a calf's skin on two sticks, and give this to the cow to lick. The calves and kids are kept in the innermost recesses of the caves during the absence of the dams at the pasturage.

Camel breeding is also a great industry among the Gara Bedouins, and the animals are remarkably fine and healthy; they have but little use for these camels, but they take them to great fairs and recognised rendezvous of the Bedouins of the interior, and sell them. The camels are curious feeders, bone being greatly appreciated by them, also small dried fish and sections of a cactus which grows in the mountains. Some of the richer Bedouins own as many as seventy camels and 500 head of cattle; they are, however, devoid of luxury, seldom constructing any habitation for themselves, and never using tents. In the wet season, when they come down to the plain of Dhofar for the pasturage, they erect as shelter for themselves round beehive huts of grass and reeds, but in the mountains they never require more than their ancestral caves, which are cool in the heat and dry in the rain, and the floors of which are springy and soft with the deposits of many generations of cattle.

The Bedouins of the Gara mountains have many interesting customs: their greetings are very complicated and curious to watch. For an acquaintance they merely rub the palms of the hands when they meet, and then kiss the tips of their fingers; for an intimate friend they join hands and kiss each other; for a relative they join hands, then rub noses, and finally kiss on either cheek.

The Gara are great believers in the existence of *Jinnis*, or spirits, in their mountains and streams. As we passed by a great rock one day they all set to work to sing the words 'Alaik Soubera,' which we were told was a request to the Jin to let us pass in safety. Again, at a lake we visited in the mountains they affirmed their belief in the existence of Jinnis, stating that it is dangerous to wet your feet in the lake, or you will catch a fever. The Jinnis inhabit the caves, the trees, and the streams; and at an annual festival and gathering of the various families into which the Gara tribe is divided, the great ceremony is the propitiating of the Jinni of the lake by a magician who sits on a rock, and performs his incantations whilst the people dance around.

They believe that the Jinnis when propitiated are very helpful to mankind; and inasmuch as they inhabit the lower heaven, they can overhear the conversation of the angels, and if disposed communicate their valuable secrets to man. This would seem to be almost the only trace of religious observance amongst the Gara Bedouin; they may have others which we were unable to ascertain, but one thing is certain, that though they may conform to the dictates of Islamism when visiting the Arab villages on the coast, when up in the mountains they observe neither prayer nor ablution, nor any of the ceremonies inculcated by that creed. The Arabs attribute to the Bedouins certain pagan rites, and they are probably correct; as in many other parts of the Mohammedan world it would seem that certain ancient cults and ceremonies have been retained, which the Moslem has been unable to eradicate.

The Gara tribe is divided into families, the chief of which is the Al Kahtan family, and the head of the Al Kahtan family is recognised as the Sheikh by all the Garas. These families have constant blood feuds amongst each other, which they make up when war is on with their neighbours, the Mahri tribe, or the Geneveh tribe. Wali Suleiman during late years has done much to heal these feuds, and it was through his instrumentality that we were enabled to penetrate into the Gara mountains, with an escort of the heads of the chief families, with comparative safety.

(3) The archæological interest in the plain of Dhofar centres chiefly in its connection with the frankincense trade and the towns established in ancient times along the coast by the merchants who provided the ancient world with the odoriferous drugs.

We have several classical authorities who refer to this district, notably Claudius Ptolemy, the author of the 'Periplus of the Red Sea,' Pliny, and a few others. From them we can gather certain definite points, that beyond Ras Fartak and the Sachalites Sinus there stretched a fertile coast line known as the Libaniferous coast. The capital of this district was according to Ptolemy called *the oracle of Artemis* (Μαντεῖον Ἀρτέμιδος), and the city next in importance was called *Abyssapolis*, near which was the harbour, the *portus nobilis*, or Moscha of the Periplus, where the merchants on their way to and from India used to tarry during the violence of the monsoons.

Along the whole line of the plain of Dhofar there are no less than seven spots where ruins occur, all indicating towns of considerable size; but on close examination of all of them there can be no manner of doubt that at Al Balad and Robat—which are about two miles from one another and connected by a series of ruins—the capital stood. These places are close to the coast, and nearly in the centre of the line of plain, and consist of the remains of many temples, tombs, and public buildings. The acropolis is well marked with the débris of buildings; there is also a tiny little harbour, evidently only for small craft, across which a chain was discovered, the Arabs say, a few years ago. Then there is a moat round the outer edge of this town, in which water is still found, and bulrushes. The columns still standing form an interesting link, which connects these ruins architecturally with the other ruined sites of the Sabæan world; they are square and fluted at each corner, and with step-like capitals. A further development of this is evidently of later origin, when they decorated the capitals with floral and geometric devices. The columns at Axsum in Abyssinia, at Koloë and Adulis on the coast of the Red Sea, and at Mariaba in Yemen, are all of the same character, and indubitably establish the Sabæan origin of the ruins. One column at Robat we found with a capital decorated on four sides, three sides with intricate geometric patterns, and the fourth with the Sabæan letters *ein* and *T* alternately. No other ruins either in size or architecture on the plains of Dhofar can compare with these, and we can safely say that they formed the capital of the district, which Claudius Ptolemy calls the oracle of Artemis (Μαντεῖον Ἀρτέμιδος), and which in later times was known as Mansura, where dwelt, Yakout tells us, the Prince of Dhofar, who had a monopoly over the frankincense trade, and punished the infringement of it with death. In later times the Persians occupied this spot, in the fourteenth and fifteenth centuries of our era. To them we owe the fact of the disturbance of the old Sabæan columns, and the utilising of them to erect mosques, many of which are now standing in a fair state of preservation.

We tried to find the site of the oracle of which Ptolemy speaks, but could not come to a satisfactory spot until we visited the mountains, and in the Wadi Nehaz, about 9 miles from the capital, just at the foot of the mountains, we found a curious natural hole, about 150 feet deep and 50 feet in diameter. Around this there was a wall of Sabæan origin which had a massive gatepost, and in the immediate vicinity were traces of many ruins. For several reasons I am inclined to believe that this is the site of the oracle mentioned by Ptolemy. In the first place, the hole resembles in character the site chosen for an oracle in the ancient world, bearing a remarkable resemblance to the holes which existed in Cilicia, the oracles of the Corycian and Olbian Zeus, and several other spots in Greece. Secondly, Yakout tells us that the abode of the Adites was half a day's journey from Mansura, the term Adites generally being given to the adherents of the ancient cult; and, thirdly, because there is no other spot on the plain of Dhofar where one can say there is a probability of an oracle existing.

Yakout further tells us that 20 parasangs from Mansura was the excellent harbour, frequented by the crafts on the way to and from India, and by merchants in search of frankincense. The author of the Periplus refers to this harbour, and calls it Moscha, and Ibn Khaldun also speaks of it as Merbat. As we journeyed along the coast we were constantly on the look out for this harbour, and on the second day, after leaving the ruins of the capital, we reached the village of Takha, in the vicinity of which are traces of many ruins scattered about, but inferior in architecture to those at Al Balad. Next morning we were conducted by the natives round a headland, and there saw a long sheet of water stretching inland, but silted up at the mouth by a sand belt, over which the sea flows at high tide. This same sand belt now separates from the shore a rocky island with traces of fortifications on it. There can be no doubt but that this is the harbour, and the island rock guarded the double entrance to it before the invasion of the sand. The harbour is deep, and extends inland about a mile and a half, and there are many ruins around it. Here we have the *portus nobilis* of the Periplus, the harbour to which the frankincense merchants came, and it is, as Yakout tells us, just 20 parasangs from the capital. The term Moscha, given to it in the Periplus, is a common term given to bays and inlets on the Arabian coast. Merbat, the name given it by Arabian writers, is still retained in the headland 12 miles east, where Arab dhows find a shelter during the north-east monsoons, but it affords no other harbourage, and Ptolemy's name for this place is Abyssapolis, a name which I consider to be derived from the great abyss which I have already described as existing a few miles inland, and which must have been a conspicuous and well-known object to all merchants who frequented this port. Ptolemy, as it will be seen from the name given to the capital, gave Greek names, or equivalents, to the places on this coast, and in naming this place he evidently used the most conspicuous object in its vicinity. Thus we were able to reconstruct on fairly probable lines the geographical features of this frankincense district, and fix the position of the sites of its towns.

Calibration of Instruments used in Engineering Laboratories.—Report of a Committee, consisting of Professor A. B. W. KENNEDY, *F.R.S.* (*Chairman*), Professor J. A. EWING, *F.R.S.*, Professor D. S. CAPPER, Professor T. H. BEARE, *and* Professor W. C. UNWIN, *F.R.S.* (*Secretary*). (*Drawn up by the Secretary.*)

AT the first meeting of the Committee it was decided to investigate initially the accuracy of instruments for measuring the tension coefficient of elasticity, or Young's Modulus. A general letter was addressed to various professors and others in charge of engineering laboratories inviting co-operation. Most of those written to agreed to make a series of measurements for discussion by the Committee.

It was then decided that sets of standard test bars should be prepared, to be subjected to tension and measurement. Figs. 1, 2 show the forms of test bar decided upon. Two of the standard bars of each set are cylindrical bars, with screwed ends of about $1\frac{1}{4}$-inch and $\frac{3}{4}$-inch diameter. These have gauge points for measuring instruments, suitable for extensometers of 8-inch, 10-inch, 16-inch, or 20-inch range. These bars are of a special steel of high tenacity, rolled specially for the Committee by the Blaenavon Company. The whole of the bars were cut from a single rolled bar about 20 feet in length, and were very accurately turned to the required dimensions by Mr. W. R. Munro. The third bar of each set was a flat bar, of section about 2 inches by $\frac{1}{2}$ inch, of mild steel. All these bars were cut from a single plate, and they were prepared with gauge points at 8 inches and 10 inches.

In order to obtain some preliminary information as to the mechanical properties of the standard bars, one round bar and one flat bar were tested in the testing machine at the Central Technical College. The following table gives the results obtained :—

Preliminary Tests of Materials used for Standard Bars.

TENSION EXPERIMENTS.

Mark on Bar	Dimensions. Inches	Area. Sq. in.	Yield Point		Maximum Load		Breaking Load		Elongation on 8 in. per cent.	Contraction of Area per cent.	E. Tons per sq. in.
			Load. Tons	Tons per sq. in.	Tons	Tons per sq. in.	Tons	Tons per sq. in.			
D	2·000 × 0·507	1·014	16·19	15·97	23·725	23·40	19·75	19·48	32	62	13,113
N	0·750 diam.	0·4418	9·00	20·37	15·725	35·59	13·76	31·14	24·5	42	

Bar D was exactly similar to the flat bars A, B, C.
Bar N was of the same steel as standard bars marked E, F, K, L, &c.

The Committee then drew up a test-sheet form to be issued with the bars, on which measurements were to be recorded. These sheets were so arranged that two sets of measurements for each bar, and the mean of these, should be recorded; also that the extensions for short and long ranges of stress should be recorded. It was hoped that in this way some measure of instrumental errors would be obtained.

In January two sets of bars were sent out for measurement, to be circulated amongst those who had consented to co-operate with the

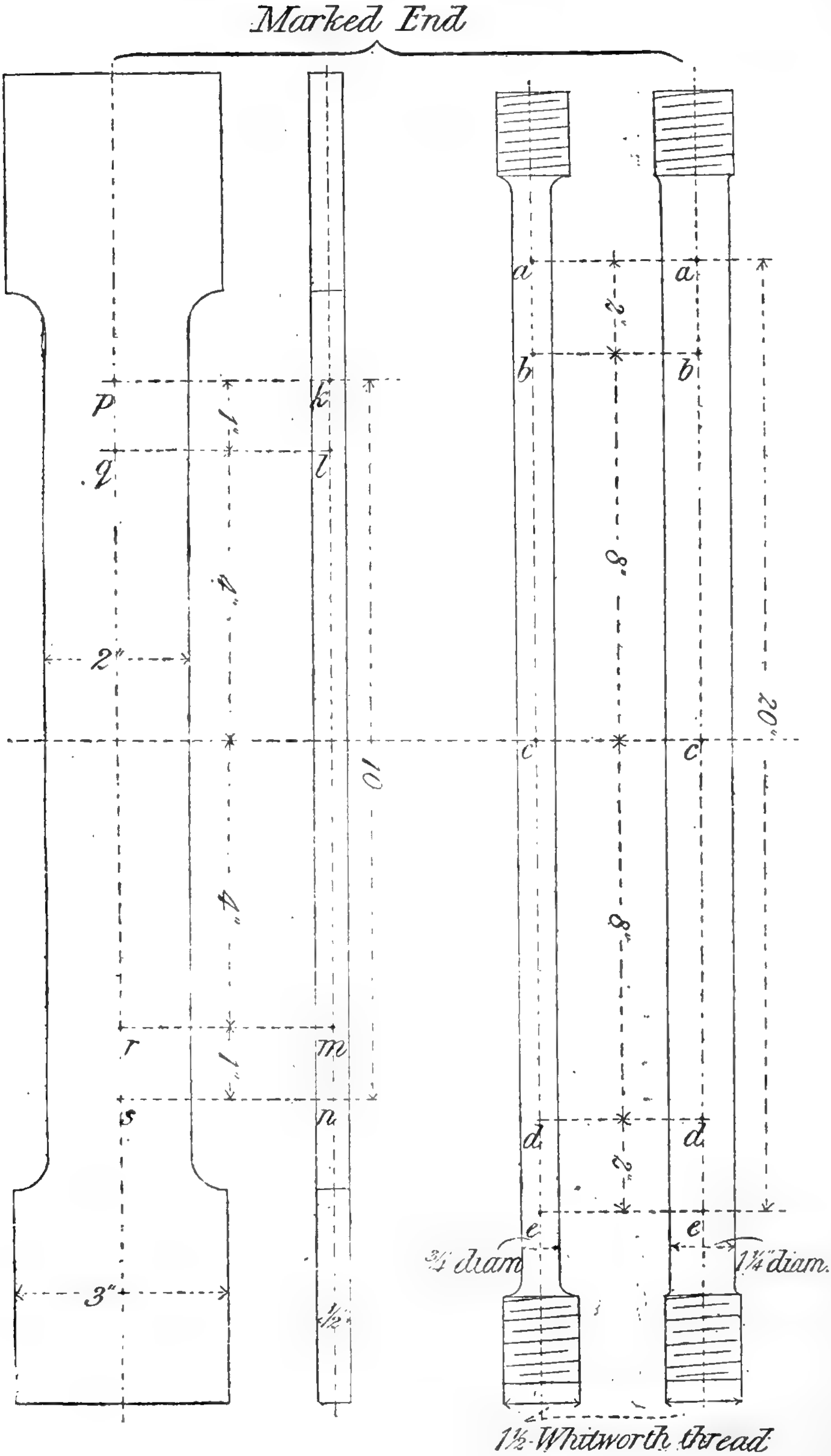

Marked End
p
q
k
l
1"
4"
2"
4"
10
r
s
m
n
1"
3"
½"
a
b
c
d
e
a
b
c
d
e
2"
8"
8"
2"
20"
¾" diam
1¼" diam.
1"
1½ Whitworth thread

FIG. 1. FIG. 2.

Committee. The measurements have taken much time, and the whole of the reports of observers have not yet been received. Some of those already sent reached the Committee too late for discussion this year. It appears, therefore, to the Committee that it is unavoidable that only an interim report can be presented this year. The Committee ask for re-appointment, in order that the results obtained may be discussed and presented.

It may, however, be useful even at this stage, to give a very short summary of some of the results sent in. The following table gives a summary of the measurements of the standard bars by different observers. It will be seen that there is an appreciable difference even in the measurement of the dimensions of the same bar. The flat bar, it may be noted, was machined on the edges only.

Measurements of Dimensions of Test Bars.

Bar	Observer	Dimensions. Inches	Area. Sq. in.
Flat Bar A	W. C. Unwin	1·999 × 0·509	1·0175
	A. B. W. Kennedy	1·998 × 0·509	1·0170
	T. Hudson Beare	2·000 × 0·5095	1·0190
	J. Goodman	1·999 × 0·509	1·0170
Flat Bar B	W. C. Unwin	1·9995 × 0·508	1·0157
	H. S. Hele Shaw	2·000 × 0·509	1·0180
	J. A. Ewing	2·000 × 0·506	1·0120
Round Bar F	W. C. Unwin	1·248 diameter	1·2230
	A. B. W. Kennedy	1·248 ,,	1·2230
	T. Hudson Beare	1·2495 ,,	1·2262
	J. Goodman	1·248 ,,	1·2230
Round Bar E	W. C. Unwin	1·249 diameter	1·2252
	H. S. Hele Shaw	1·247 ,,	1·22125
	J. A. Ewing	1·249 ,,	1·2250
Round Bar L	W. C. Unwin	0·7495 diameter	0·4412
	A. B. W. Kennedy	0·748 ,,	0·4394
	T. Hudson Beare	0·750 ,,	0·4418
	J. Goodman	0·748 ,,	0·4390
Round Bar K	W. C. Unwin	0·750 diameter	0·4418
	H. S. Hele Shaw	0·750 ,,	0·44179
	J. A. Ewing	0·750 ,,	0·4418

The following table gives the values of the coefficient of elasticity for the greatest range of stress observed for each bar. The values are given for the first and second loading of the bar, and also the mean of the two observations. It will be seen that, even for the mean of two sets of readings, over the greatest range of stress the elasticity of the bar permits, there are very appreciable differences in the values obtained. It remains to be considered in a more detailed discussion of the results whether any evidence can be found as to the source of the discrepancies. It may be due to error of the testing machine, to error of magnification by the extensometer, or to error of calibration of the extensometer. It is just possible it may be due in part to temperature or other action independent of both testing machine and extensometer.

General Values of E obtained for the greatest range of stress the bar permitted.

Bar	Gauge Points	Observer	Range from which E was calculated	Values of E. Tons per square inch		
				First Loading	Second Loading	Mean
			Tons			
Flat bar A	p. s.	T. Hudson Beare . .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,160	13,260	13,210
	p. s.	A. B. W. Kennedy . .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,100	13,200	13,150
	—	John Goodman . .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,110	13,110	13,110
$1\frac{1}{4}$ bar F	a. c.	T. Hudson Beare . .	$2\frac{1}{2}$ to 20	13,050	13,150	13,100
	c. d.	T. Hudson Beare . .	$2\frac{1}{2}$ to 20	13,070	13,150	13,110
	c. e.	A. B. W. Kennedy . .	$2\frac{1}{2}$ to 20	13,430	13,430	13,430
	—	J. Goodman . . .	$2\frac{1}{2}$ to 20	13,250	13,250	13,250
	—	J. Goodman (students) .	$2\frac{1}{2}$ to 20	13,250	13,370	13,310
	a. c.	A. B. W. Kennedy . .	$2\frac{1}{2}$ to 20	13,500	13,500	13,500
$\frac{3}{4}$ bar L	a. c.	T. Hudson Beare . .	$1\frac{1}{4}$ to $6\frac{1}{4}$	13,260	13,420	13,340
	c. d.	T. Hudson Beare . .	$1\frac{1}{4}$ to $6\frac{1}{4}$	13,210	13,160	13,185
	a. c.	A. B. W. Kennedy . .	$1\frac{1}{4}$ to $6\frac{1}{4}$	13,200	13,200	13,200
	—	J. Goodman	$1\frac{1}{4}$ to $6\frac{1}{4}$	13,244	13,244	13,244
	—	J. Goodman (students) .	$1\frac{1}{4}$ to $6\frac{1}{4}$	13,720	13,720	13,720
Flat bar B	k. n.	W. C. Unwin (mirror) .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,294	13,302	13,298
	l. m.	W. C. Unwin (lever) .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,260	13,260	13,260
	l. m.	H. S. Hele Shaw . .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,180	13,060	13,120
	—	J. A. Ewing . . .	$2\frac{1}{2}$ to $12\frac{1}{2}$	13,260	13,310	13,285
$1\frac{1}{4}$ bar E	a. c.	W. C. Unwin (mirror) .	$2\frac{1}{2}$ to 20	13,198	13,231	13,214
	c. d.	W. C. Unwin (lever) .	$2\frac{1}{2}$ to 20	12,912	12,969	12,940
	—	H. S. Hele Shaw . .	$2\frac{1}{2}$ to 20	13,116	13,160	13,138
	—	J. A. Ewing . . .	$2\frac{1}{2}$ to 20	13,290	13,290	13,290
$\frac{3}{4}$ bar K	—	H. S. Hele Shaw . .	$1\frac{1}{4}$ to $7\frac{1}{2}$	13,310	13,072	13,191
	a. c.	W. C. Unwin . . .	$1\frac{1}{4}$ to $7\frac{1}{2}$	13,495	13,385	13,440
	—	J. A. Ewing . . .	$1\frac{1}{4}$ to $7\frac{1}{2}$	13,380	13,350	13,365

An Ancient Kitchen Midden at Hastings, and a Barrow at the Wildernesse.—Report of the Committee, consisting of Sir JOHN EVANS (*Chairman*), Mr. W. J. LEWIS ABBOTT (*Secretary*), Professor J. PRESTWICH, Mr. CUTHBERT PEEK, *and* Mr. ARTHUR J. EVANS. (*Drawn up by the Secretary.*)

The Hastings Kitchen Middens.

THE cliffs at Hastings are formed of sandstones belonging to the Ashdown Sands, which at Castle Hill rise some 180 feet in height. These are very much fissured, and often a centre block becomes keyed above, while it breaks away below, thus forming a veritable cave. Along both the east and west cliffs these natural fissures have been widened out artificially, and doubtless have served as human habitations in the past.

Upon the tops of some of these fissures, and upon the rock-ledges on the face of the cliffs, there are large accumulations of materials of various kinds, the upper part of which is a subaërial deposit, which varies in thickness from an inch or two up to four feet. Below this is the midden material, composed of all sorts of the waste products of life. It is usually only a few inches in thickness, but occasionally it is eighteen inches thick. It is much darker than the adjacent material, owing to the large quantity of charcoal and other carbonaceous matter contained in it. Frequently there are hearths which occur on old surfaces, where the material has been burnt to a red-brick mass, extending downwards from half an inch to three inches; in wet weather this is very friable and rotten. In places there are seams of shells: the most extensive layers consist of those of mussels and oysters, which are in the worst state of preservation. Limpets are almost as plentiful, but better preserved than the former. Winkles are very abundant, and always of very large size. *Buccinum undatum* is fairly plentiful, but *Trophon* is absent. *Cardium echinatum* is frequently found, but no trace of *C. edule* has been observed. The occurrence of *Purpura lapillus* is curious. Some pieces of bone have recently been discovered stained of a purple colour, which would suggest a knowledge of the dye furnished by this species. *Pecten opercularis*, *Natica*, and *Mactra* also occurred, while in one place a heap of snail-shells of a very large size was found: these are probably *Helix aspersa*, but the shells are larger and more globose than those of the existing species, and the light-brown bands of colour that are left make the species to resemble *H. pomatia*. There is also a large quantity of fish-bones distributed through the material, some of which bear traces of roasting: they include skate, gurnard, cod, whiting, mackerel, sole, turbot, and plaice. Large quantities of other bones formed part of the material; they are always detached, and bones are never found together in the natural position; frequently they show the action of fire, and all the marrow-bones are split. In two cases a split bone was discovered with a flint wedge still *in situ*. The bones include those of frog, ducks, some species of gull, red and black grouse, and other species of birds not yet determined; rabbit, pig, horse, sheep, goat, red deer, roe, ox, badger, fox, wolf, dog.

Fragments of pottery abound occasionally; it is possible to restore about a third part of a vessel, from which its nature and shape can be determined. They are all of domestic patterns (not burial), flat-bottomed, and they usually have a deposit of soot upon them. Some appear to be very coarse and sun-dried, but the majority are well-baked and hand-made. They vary in colour from a discoloured dirty red to black, the latter predominating. They are, on the average, of good neolithic quality.

Large quantities of flint boulders appear to have been taken up for implement-making. All the implements are small; no axe or war implement has been discovered. Many hundreds of flakes show signs of wear, and these sometimes reach five inches in length. Round and hollow scrapers abound, from a very large size down to needle-makers, as do all kinds of drills. None of the arrow or lance heads are barbed, but they are often very symmetrically worked to a lanceolate shape. The commonest form is a nicely worked lanceolate-shaped flake, single or double ridged, generally the latter, with a well-formed butt, with or without secondary work on the edges. The butt ends of hundreds of these have been found, the points excessively rarely. There is, however, a still more interesting group of implements than any of the foregoing, owing to their diminutive size, their peculiar outlines, and delicate work—implements in every way similar to those which have been found in

India, Egypt, the South of Spain, and Belgium abroad, while in this country they have been recorded from N.E. Lancashire, Warren Hill, Hastings, and Sevenoaks. They consist of crescents, triangles, trapezoids, and other forms. They are sometimes only five-eighths of an inch in length, and rarely exceed one and a half inch. The flakes removed in their manufacture are often only an eightieth of an inch in width.

A more systematic method of working was adopted during the month of August of this year, adding a vast amount of new material which has yet to be examined, and more work remains to be done. In spite of the vigilance of those in charge, visitors dig into the cliff, and so expose the midden material to the action of the heavy rains, by which it is washed away and lost.

The best thanks of the Committee are due to the Mayor and Corporation of Hastings for the interest they have taken in the subject, and also for the permission given to excavate; and to the Rev. W. C. Sayer-Milward, whose permission to excavate was also necessary.

A Remarkable Barrow at the Wildernesse, Sevenoaks, Kent.

This barrow is situated near a Neolithic settlement on the property of Lord Hillingdon at Sevenoaks.

The bed-rock of the district belongs to the Folkestone beds, and is usually of a deep iron-stained colour. Upon this was deposited a layer of siliceous ironstone, which apparently served as a hearth, then a layer of black carbonaceous unctuous material, through which are distributed fragments of charcoal and small particles of burned bone. This is followed by a layer of calcined flints, all of which appear to have been worked; but the heat applied was so intense that all the flints are in fragments, and the edges are frequently fused. It is possible, however, to restore implements from fragments found close together. These layers were covered by and enclosed in another black carbonaceous layer, in which occur fairly large pieces of charcoal. Next comes another layer of ironstone. This is followed by a layer of white sand: profusely distributed through these are large quantities of flint implements, flakes, &c. This is a foot in thickness near the centre, where the whole of the flints show signs of burning. The latest excavations disclose the lateral extension of the white layer till it is met by the overlying 4 ft. 6 in. of sand.

The barrow is round in form, about 90 feet in diameter, and 5 ft. 6 in. high.

The implements are in every way identical with those found on the adjoining settlement and at the Hastings Kitchen Middens. There are more horseshoe-shaped scrapers than at Hastings, where the scrapers are nearly all spatulate in form; but all the curiously shaped, diminutive crescents, triangles, trapezoids, &c., are also found at Sevenoaks; in fact, it is impossible to distinguish between them.

No metal was found in the barrow except a brass-covered iron bell in the top material. The Rev. Canon Greenwell is of the opinion that this barrow is quite unique.

The barrow has now been filled in again.

The Committee propose to spend the small balance in hand upon the Kitchen Middens on Castle Hill. There are others on the East Hill which would also repay working. These middens are intimately associated with the remarkable St. Clement's Caves, and an investigation of them might possibly throw a flood of light upon the unknown origin of these structures.

Anthropometric Measurements in Schools.—Report of the Committee, consisting of Professor A. MACALISTER (*Chairman*), Professor B. WINDLE (*Secretary*), Mr. E. W. BRABROOK, Professor J. CLELAND, *and* Dr. J. G. GARSON.

DURING the past year it has not been deemed advisable to issue any further circular, and the work done has been confined to forwarding copies of the instructions printed with last year's report and advising schoolmasters, medical men, and others as to the taking up and carrying on of physical measurements in the institutions with which they are connected.

From the number of communications which have reached the Secretary, it is evident that considerable interest has been awakened in the minds of teachers by the circulars of last year. The first report of school measurements (by Dr. Lancelot Andrewes) which have been carried out under its instructions has recently been forwarded to the Secretary. The Committee ask for reappointment for another year without further grant, the balance of that for 1894–95 being expected to suffice for the ensuing twelvemonth.

Mental and Physical Defects of Children.—Report of the Committee, consisting of Sir DOUGLAS GALTON (*Chairman*), Dr. FRANCIS WARNER (*Secretary*), Mr. E. W. BRABROOK, Dr. J. G. GARSON, *and* Dr. WILBERFORCE SMITH. (*Report drawn up by the Secretary.*)

THE Committee, acting in conjunction with a committee appointed for the same purpose by the International Congress of Hygiene and Demography (1891), in presenting their third report are able to give a further account of the 50,000 children seen individually during the years 1892–94.

The methods of observation and the points observed were fully described in our first report. Analysis of the points observed in each child affords material for the arrangement of groups of cases, prepared by established actuarial processes, their distribution, and their co-relations, and enables us to give results of scientific interest and importance, and also to give evidence on questions concerning the education of children and their control by the State.

We proceed to give the results of research among the 8,941 cases (boys 5,112, girls 3,829) of whom notes were taken as to the points in which they were below the average in bodily or mental status.

As a step towards ascertaining the causation of defects, and the most probable means of removing them, we have arranged the children in twelve groups of schools presented in Table I., which gives the 'numbers seen' and 'the numbers noted' in each group of schools respectively, and the special defects they presented. It is thus possible to ascertain the relative frequency of each defect among the boys and girls of the nationalities and social classes, &c.

The numbers of cases presenting individual defects, when distributed among the nationalities and social classes, &c., are comparatively small; for the general purposes of research it appears more satisfactory to deal with groups of cases presenting the main classes of defects. For this reason the Committee have bestowed much labour on preparing a general but exact analysis of the facts in hand, dealing principally with the distribution and co-relations of the main classes of defects, leaving for future work the study of similar relations among the individual signs in such classes.

There are four main classes or divisions into which the defective conditions observed may be grouped.

A. *Defects in development* of the body and its parts—in size, form, or proportioning of parts.

B. *Abnormal nerve-signs*: certain abnormal actions, movements, and balances.

C. *Low nutrition*, as indicated by the child being thin, pale, or delicate.

D. *Mental Dulness.*—The teacher's report as to mental ability was added to the record of each child noted, and those stated to be backward or below the average in ability for school work were entered as 'dull.'

The relative distribution of these classes of defects is shown in Table II., which also gives the combinations in which they occur, and their percentages upon the numbers of children seen and the numbers noted. It is by studying the distribution and the co-relations of these groups that new information is most readily obtained.

Among the children who present some degree of defect those are probably in best condition who present only 'one main class of defects,' while those with four classes of defects are often so deficient as to need special care and training. The numbers and percentages of these groups are also given in Table II.

A full statement of the facts observed has been prepared for early publication by the committee with whom we are allied, which enables us to make certain general statements upon which their report will afford detailed evidence.

Defects in development of the body are more frequent among boys than girls—in the proportion of 8·7 to 6·8. A marked exception to this rule is in the cases of small cranium, which are much more frequent among girls: this defect appears to some degree endemic in the neighbourhoods of large buildings. It is less frequent among the Irish children, who in other particulars present many noteworthy points.

Of the cases with defect in development (A), 16·2 per cent. of the boys and 26·4 per cent. of the girls were pale, thin, or delicate; and 38·4 per cent. of the boys and 45·0 per cent. of the girls were reported as dull.

These facts serve to illustrate the importance of presenting all vital statistics separately for males and females. The greater harm that results from defect of body among girls is shown by the fact that 65·3 per cent. of the boys and 72·5 per cent. of the girls presented other conditions of defectiveness. The evidence accumulated shows the importance of looking to the four main classes of defect in each case. It has not been possible in our examinations conducted in schools to use anthropometric methods to any extent, but new information has been supplied upon an extended basis of observation as to the significance of deviations from the normal proportioning of the bodily development.

It has been fairly established by observation, independent of arguments derived from other sources, that the 'nerve-signs' recorded in this investigation correspond to disordered brain conditions, such as produce in their mental function dull and backward children.

Of cases with 'nerve-signs' 41·5 per cent. of boys, 42·6 per cent. of girls were reported as dull; of development defect with 'nerve-signs,' 45·1 per cent. of boys, 51·6 per cent. of girls, were reported as dull. Ill-proportioned bodies with motor indications of disorderly or slowly acting brains are very apt to be dull mentally. In these facts we find further evidence of a physical basis of mental action and expression. The probability that the children reported by the teachers as dull were backward children is indicated by the large proportion of them found to be over age for the class or educational standard in which they had been placed in school.

In Table I. is given a class, 'G. Exceptional Children.' This includes all children whose physical or mental conditions show them to be obviously at a permanent disadvantage therefrom in social life. This group includes idiots, imbeciles, 'children feebly gifted mentally'; children mentally exceptional or deficient in moral sense; epileptics and children with history of fits during school life; dumb children and all children crippled, deformed, maimed, or paralysed. All these exceptional children need to be considered individually: they form about 1·5 per cent. of the school population.

Reviewing the work of which we thus give a brief account, it may be stated that the object has been to furnish a reliable statement of the conditions observed among children seen in schools. The inquiry commenced in 1888, and 100,000 children in all have been examined and reported on. The points worthy of note have been defined and enumerated; the children have been distributed in groups according to the combinations of points they presented, and classified in other ways, including special particulars as to the children with mental or other deficiency, the numbers in each class being recorded. The methods of reporting and preparing statistical statements have been carefully elaborated and systematised.

Information has from time to time been supplied to the Government departments and other public bodies as to the provision needed for dull and backward children; the classification of children in schools providing secondary education; children in Poor Law schools and other institutions, and on other important questions.

It is hoped that the scientific classification of children and enumeration of conditions existing among them will lead to the adoption of means of social improvement, and we recommend the continuation of such inquiries in other parts of the country.

The Committee desire to be reappointed, and ask a grant in aid of the work.

Table I.—*Showing the Numbers of the Main Classes of Defects and noted distributed in Groups of Schools representing*

—	School Groups I. to XII. — Total Nos.		London Board Schools English Children Upper Social Class — I.		London Board Schools English Children Average Social Class — II.		London Board Schools English Children Poorer Social Class — III.		London Board Schools Jewish Children Poorer Social Class — IV.	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Number of children seen	26,287	23,713	4,800	4,316	6,113	5,628	6,242	5,213	1,368	1,581
Number of children noted	5,112	3,829	838	679	1,159	944	1,155	863	249	223
A. *Cases with defect in Development alone or in combination*	2,308	1,618	396	272	510	385	548	391	126	101
1 Cranium defective	806	611	120	74	159	142	200	173	55	48
2 „ large	107	13	19	2	19	4	31	3	6	—
3 „ small	149	516	15	61	27	127	52	155	12	35
4 „ bossed	323	47	49	5	59	10	65	6	29	10
5 Forehead defective	53	23	4	2	14	6	10	3	2	2
6 Interfrontal ridge	121	19	28	3	27	5	22	3	5	1
7 Cranium asymmetrical	27	2	2	1	8	—	10	1	—	—
8 Dolichocephalic	26	2	4	—	5	—	7	2	2	—
9 Hydrocephalic	2	1	—	—	—	—	1	—	—	1
10 Other types of cranium	11	2	2	—	—	1	6	—	1	1
11 External ear defective	364	103	62	21	69	22	73	24	29	11
12 Eyelids with epicanthis	288	190	53	45	63	40	79	41	5	7
13 Palate defective in form	496	310	104	71	131	77	97	55	13	11
14 „ narrow	276	163	69	42	72	38	55	27	6	8
15 „ V-shaped	179	110	30	24	43	29	35	22	7	3
16 „ arched	30	22	3	3	13	4	4	4	—	—
17 „ cleft	12	13	2	2	4	5	3	2	—	—
18 Other types of defective palate	—	1	—	—	—	—	—	—	—	—
19 Nasal bones wide, sunken	155	153	16	15	42	31	37	49	9	6
20 Growth small; stature short	271	328	46	58	65	79	68	105	12	17
21 Other defects in development	250	212	37	42	60	38	58	40	15	20
B. *Cases with Abnormal Nerve-signs alone or in combination*	2,853	2,015	423	342	644	492	601	437	132	109
43 General balance defective	90	113	11	18	18	21	9	31	9	11
44 Expression defective	151	191	19	32	38	40	39	57	10	11
45 Frontal muscles overacting	696	146	107	28	127	25	157	37	26	11
46 Corrugation; knitting eyebrows	38	11	4	1	9	2	8	4	—	—
47 Orbicularis oculi relaxed	371	293	61	44	78	82	93	87	9	5
48 Eye movements defective	348	261	52	57	60	62	95	65	23	27
49 Head balance asymmetrical	95	274	6	49	17	55	22	75	9	14
50 Hand balance weak	1,234	778	175	135	298	201	209	118	55	29
51 Hand balance nervous	253	359	25	48	70	104	63	85	11	26
52 Finger twitches	145	142	23	22	38	34	32	32	4	10
53 Lordosis	36	112	6	30	3	18	6	20	4	10
54 Other abnormal nerve-signs	468	282	78	43	100	58	121	72	35	24
C. *Cases with low nutrition*	749	770	104	117	180	199	195	205	36	46
D. *Children reported as dull or backward*	2,077	1,635	294	233	539	447	511	394	134	111
E. *Eye cases*	764	692	142	142	172	153	169	129	30	42
G. *'Exceptional children'*	157	147	17	21	30	37	56	34	12	14

certain Individual Defects; also the Numbers of Children seen and the Nationalities, Social Classes, &c.

Country Board Schools English Children Average Social Class		Edinburgh Board Schools Upper Social Class		Voluntary Schools English Children Upper Social Class		Voluntary Schools English Children Average Social Class		Voluntary Schools English Children Poorer Social Class		Voluntary Schools Irish Children Poorer Social Class		Voluntary Schools Jewish Children Average Social Class		Voluntary Schools Jewish Children Poorer Social Class	
V.		VI.		VII.		VIII.		IX.		X.		XI.		XII.	
Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
528	481	803	807	974	939	968	988	697	720	2,171	1,952	823	693	440	394
105	70	163	128	250	162	228	158	137	96	535	324	138	104	155	78
45	33	64	37	96	55	96	70	58	44	252	163	68	44	49	23
12	9	15	12	31	17	48	28	24	16	111	65	18	19	13	8
1	1	3	—	8	1	4	1	4	—	11	—	—	1	1	—
4	7	2	7	2	12	8	23	3	15	16	52	5	16	3	6
4	1	5	4	11	—	17	2	14	1	54	6	8	1	8	1
1	—	2	—	2	1	5	2	—	—	11	5	1	1	1	1
2	—	2	1	6	3	10	—	2	—	14	2	3	1	—	—
—	—	—	—	2	—	2	—	—	—	2	—	1	—	—	—
—	—	—	—	1	—	4	—	1	—	2	—	—	—	—	—
—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
7	2	20	5	22	2	9	2	5	—	39	9	19	3	10	2
9	5	7	2	8	6	6	9	15	10	23	17	16	8	4	—
13	10	16	10	28	14	19	14	10	8	45	28	12	8	8	4
10	6	7	8	11	6	9	6	4	4	24	15	4	2	5	1
3	4	8	2	16	6	8	4	5	3	16	8	6	3	2	2
—	—	1	—	1	—	2	3	—	1	4	3	1	3	1	1
—	—	—	—	—	2	—	—	1	—	1	2	1	—	—	—
—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
6	3	3	2	2	6	6	9	1	10	27	17	2	3	4	2
3	3	7	7	8	7	9	13	5	6	29	24	5	6	14	3
6	8	7	6	12	13	11	9	6	3	26	21	5	4	7	8
63	39	105	83	156	96	148	82	78	55	322	177	83	63	98	40
4	4	8	2	3	1	5	1	2	4	10	12	4	4	7	4
5	1	3	6	1	4	11	8	2	4	12	20	9	5	2	3
11	1	11	3	22	—	40	6	29	3	131	27	15	4	20	1
1	—	1	4	1	—	1	—	—	—	11	—	2	—	—	—
5	3	7	5	37	20	26	14	15	12	20	16	12	5	8	—
9	8	1	3	24	8	14	6	9	2	30	11	10	8	21	4
5	10	6	4	2	11	8	13	2	2	13	28	2	9	3	4
39	18	79	55	83	43	55	40	28	20	124	68	37	28	52	23
7	7	—	4	18	22	14	5	9	5	23	34	8	14	5	5
6	7	—	—	7	11	13	3	5	1	13	19	2	3	2	—
1	—	4	7	3	6	2	1	1	1	2	7	2	7	2	5
9	7	16	11	17	8	20	12	9	10	37	20	9	9	17	8
10	12	18	27	26	21	49	31	18	19	71	75	16	9	26	9
32	34	73	51	80	60	83	66	69	47	182	127	47	28	33	37
10	13	34	23	37	33	39	35	24	15	67	59	20	26	20	22
3	3	5	2	2	3	6	10	3	5	16	14	4	2	3	2

TABLE II.—*Giving the Cases noted as showing some Defect, distributed in Groups presenting the Defects named only, and their Percentages on the Number noted and on the Number seen respectively. Also giving the Numbers and Percentages of the Groups with one, two, three, or four Defects respectively:—*

Primary groups—presenting only the main class of defects indicated	Number of cases and percentages taken on number of children noted				Percentages taken on the number of children seen	
	Boys		Girls		Boys	Girls
	No.	Per cent.	No.	Per cent.	Per cent.	Per cent.
A. Cases with defect in development only	802	15·7	445	11·5	3·0	1·9
B. " " abnormal nerve-signs only	1059	20·7	762	19·7	4·0	3·2
C. " " low nutrition only	108	2·1	110	2·8	·4	·5
D. Children dull or backward only	331	6·5	297	7·7	1·3	1·2
Groups with only one main class of defect	**2300**	**45·0**	**1614**	**41·7**	**8·7**	**6·8**
AB. Cases with defect in development and nerve-signs only	415	8·1	207	5·4	1·6	·9
AC. Cases with defect in development and low nutrition only	134	2·6	162	5·2	·5	·7
AD. Cases with defect in development and dull or backward only	394	7 7	314	8·2	1·5	1·3
BC. Cases with abnormal nerve-signs and low nutrition only	115	2·2	109	2·8	·4	·5
BD. Cases with abnormal nerve-signs and dull or backward only	703	13·7	487	12·6	2·7	2·0
CD. Cases pale, thin, or delicate, and dull or backward only	63	1·2	53	1·3	·2	·2
Groups with only two main classes of defect	**1824**	**35·5**	**1332**	**35·5**	**6·9**	**5·6**
ABC. Cases with defect in development, with nerve-signs and low nutrition only	69	1·4	77	2·0	·2	·3
ABD. Cases with defect in development, with nerve-signs and dull or backward	323	6·3	224	5·8	1·2	·9
ACD. Cases with defect in development, with low nutrition and dull or backward	91	1·8	110	2·8	·3	·5
BCD. Cases with nerve-signs, low nutrition, and dull or backward	89	1·8	70	1·8	·3	·3
Groups with only three main classes of defect	**572**	**11·3**	**481**	**12·4**	**2 0**	**2·0**
ABCD. Dull children with nerve-signs, defect in development, and pale, thin, or delicate	80	1·6	79	2·0	·3	·3
EFG. Cases without any main class of defect	336	6·6	323	8·4	1·3	1·4
Total of cases noted with some defect	5112	100·0	3819	100·0	19·2	16·1

Ethnographical Survey of the United Kingdom.—Third Report of the Committee, consisting of Mr. E. W. BRABROOK (*Chairman*), Mr. FRANCIS GALTON, Dr. J. G. GARSON, Professor A. C. HADDON, Dr. JOSEPH ANDERSON, Mr. J. ROMILLY ALLEN, Dr. J. BEDDOE, Professor D. J. CUNNINGHAM, Professor W. BOYD DAWKINS, Mr. ARTHUR EVANS, Sir H. HOWORTH, Professor R. MELDOLA, General PITT-RIVERS, Mr. E. G. RAVENSTEIN, *and* Mr. E. SIDNEY HARTLAND (*Secretary*). (*Drawn up by the Chairman.*)

1. As in the two previous years, the Committee have had the advantage of the co-operation of several gentlemen not members of the Association, but delegates of various learned bodies who are interested in the Survey. They have to deplore the loss, by death, of one of these gentlemen, Mr. Granville Leveson-Gower, one of the delegates of the Society of Antiquaries. His place has been filled by the election by the same Society of its Director, Mr. F. G. Hilton Price, as a delegate to this Committee. His colleague, Mr. George Payne, and Mr. E. Clodd, Mr. G. L. Gomme, and Mr. J. Jacobs, the representatives of the Folk Lore Society, Sir C. M. Kennedy, K.C.M.G., representing the Royal Statistical Society, Mr. Edward Laws, the Ven. Achdeacon Thomas, Mr. S. W. Williams, and Professor John Rhys, representing the Cambrian Archæological Association, and Dr. C. R. Browne, a representative of the Royal Irish Academy, have continued their valuable services. Some other members of the Committee are delegated by the Anthropological Institute.

2. In their first and second reports, the Committee presented a list of 367 villages or places which, in the opinion of competent persons consulted by the Committee, appeared especially to deserve ethnographic study, and they appended to the list observations furnished by their correspondents on the special characteristics of such villages and places, which rendered them typical. This considerable number does not exhaust the supply of names of places, several observations having been made in places not mentioned in the list.

3. The Committee have issued, in the shape of an octavo pamphlet of twelve pages only, the forms of schedule which they had prepared. They believe that it presents, in the most compendious manner possible, a body of instructions for observers under the five heads into which the Committee's inquiries have been divided, viz. :—

(1) Physical types of the inhabitants ;
(2) Current traditions and beliefs ;
(3) Peculiarities of dialect ;
(4) Monuments and other remains of ancient culture ; and
(5) Historical evidence as to continuity of race.

Arrangements have been made with the printers for supplying this pamphlet to Societies which may be desirous of circulating it among their members or incorporating it with their Transactions, at a cost of 21*s.* for every 400 copies, or 16*s.* if printed on the Society's own paper. [See circular in Appendix.]

4. This offer has been accepted by several societies. One of the societies which have availed themselves of the arrangement is the Bristol and Gloucestershire Archæological Society, and Mr. Hartland has prepared for insertion in its Transactions some notes explanatory of the Schedule, a copy of which is appended to this report. The Committee propose to arrange with the Society for a supply of copies of these notes, which may be useful to societies and observers in other parts of the country.

5. During the year the work of observation has been proceeding in several directions, and the sub-committees in various parts of the United Kingdom have commenced operations. The Committee do not propose at the present stage to present any report of the results of these observations, but only to report progress and to request their reappointment for the purpose of continuing the work with which they have been entrusted.

6. They desire to make an exception, however, in the case of Ipswich, which possesses local interest as being the place of meeting of the Association for the present year. Miss Layard has acted as secretary of a sub-committee in Ipswich, and Dr. Hetherington has furnished twenty measurements of individuals, a report upon which has been prepared by Dr. Garson, and will be presented in a future report. Dr. Groome, Mr. Partridge, and Mrs. Ledger have also contributed, through Miss Layard, collections of the local Folklore, and these will also be contained in a future report. By the courteous invitation of Mrs. Cobbold, the Chairman and Secretary of the Committee attended a meeting at her house for the purpose of explaining the views of the Committee, at which much interest was expressed in the work of the Committee, and some valuable information was obtained.

7. Some interesting investigations have also been made by the Committee at Barley, in the county of Hertford. Their attention was drawn by the Rector, the Rev. J. Frome Wilkinson, to the strong historical evidence as to continuity of race furnished by entries in the parish registers and other local records going back to an unusually early time, to the existence of remains of ancient culture hitherto almost unnoticed in the county histories, and to the survival to a late period of early forms of land cultivation in this parish. By his courtesy, Professor Haddon, who was accompanied by the Chairman of the Committee, was able to take measurements and photographs of inhabitants of the parish belonging to different ranks of society, whose pedigrees could be traced through the registers for a considerable period.

8. A Cambridge University sub-committee for the Ethnographical Survey of East Anglia has been formed to discover and record the principal types of the inhabitants of East Anglia on the lines laid down by this Committee, under the auspices of the Royal Society. This sub-committee consists of Professor Macalister, F.R.S., Mr. W. L. H. Duckworth, and Professor Haddon, under whose supervision the work will be conducted by a number of trained men. The work of forming sub-committees in Wales has also been proceeded with. In the Cotteswolds, Mr. S. S. Buckman has furnished the committee with notes introductory to observations that are in progress.

9. The Committee have been anxious to procure observations (especially physical observations) from places where the non-existence of any local society or other reasons may interpose difficulties in the way of the

formation of a sub-committee. With this view, a circular has been addressed to a selected number of medical men, whose names were obtained from the lists of those who had contributed to the researches of the Collective Investigation Committee of the British Medical Association. [See Appendix.] As yet, however, the Committee have not been fortunate in obtaining the favourable response to their application to these gentlemen for which they had hoped.

10. The Committee propose, at the close of the present meeting, to arrange for a special survey of the district of Galloway, during the latter part of September and the month of October 1895, with the view of ascertaining the special divergencies in dialect, the prehistoric monuments, the old cultivation sites, the folklore, the physical types of the people, and objects of obsolete culture in domestic and agricultural occupations. The Committee are glad to find that the Rev. Dr. Walter Gregor, author of 'Notes on the Folklore of the North-east of Scotland' and other works, is willing to undertake this survey. The expense is estimated at not more than 20*l.*

11. Should Dr. Gregor's time allow, they hope he may be induced, later in the year 1895–96, to undertake a similar survey in the districts of Caithness, Morayshire, and Nairn.

12. Only 10*l.* has been drawn in the past year out of the 30*l.* voted at the Oxford meeting, although more has been expended. The Committee ask for a renewal of the 20*l.* not drawn, and for a further grant of 30*l.*, making 50*l.* altogether.

APPENDIX I.

Circular to local Societies.

DEAR SIR,—I am instructed by the Ethnographical Survey Committee to send you herewith a copy of the schedules prepared for the purpose of the inquiry entrusted to them into the mental and physical characteristics of the races of the United Kingdom. The heads of inquiry, as you will see, are very various; and it is hoped that some at least of them will interest the members of your Society. With the object of making them as widely known as possible, the Committee have arranged with the printers (Messrs. Spottiswoode & Co., New Street Square, London, E.C.) to supply copies to you, upon request, at the rate of 1*l.* 1*s.* for 400 copies, or, if your own paper be used, 16*s.* By this means you will be enabled to issue them with your transactions, or report, or to take any other means which may appear more suitable to bring the subject under the notice of all your members.

You will observe that villages and retired places are spoken of in the accompanying print as especially deserving of ethnographic study. The object is to devote attention chiefly to the inhabitants of districts where the population has long been stationary and little changed by the movements of modern life. It is desired to obtain physical measurements and photographs of individuals who appear typical in their respective districts, individuals selected, if possible, from among those whose forefathers have dwelt in the neighbourhood as far back as can be traced. With the physical peculiarities of the people it is desired to correlate their dialect, their history as exhibited by archæological remains, and their manners and customs, superstitions and other traditions comprehended under the convenient expression of Folklore.

The inquiry has already been taken up with earnestness in some districts, and valuable results have been obtained; and the Committee think that, when once its importance to the right understanding of the history and characteristics of the races of these islands is fully appreciated, little difficulty will be found in organising measures in every county for collecting and collating the information. The report of a committee appointed by a local society would not only be gratefully received by the Ethnographical Survey Committee; but it might also be embodied in the transactions of the local society, and thus form a substantial contribution to the history and archæology of the county.

The Committee will be pleased to arrange for the loan of a set of instruments, if desired, to any member of your Society who may undertake the physical measurements. If the procuring of photographs be found to involve expense beyond that which your Society is prepared to meet, the Committee will be glad to be informed, in order that, if practicable, they may make some contribution towards it. I may observe, however, that many local societies are now undertaking a photographic survey of their neighbourhoods; and where this is in progress the photographing of typical inhabitants will not entail much additional labour or cost, while it will add greatly to the value of the survey. I shall be obliged by your informing me what number of measurements of individuals you think your Society may be able to obtain, so that the necessary copies of the form may be sent.

APPENDIX II.

Circular to Medical Men.

Dear Sir,—I am desired by the Ethnographical Survey Committee of the British Association to transmit to you herewith a copy of the forms of schedules that have been prepared for the purpose of the inquiry entrusted to them into the physical and mental characteristics of the races of the United Kingdom, and to express the hope that you may be able to assist them by obtaining a series of the physical measurements of individuals who appear to you to be typical of the district in which you reside. It is suggested that those individuals should be selected whose parents and progenitors have lived in the district as far back as can be traced.

You will observe that the desire of the Committee is to correlate the physical racial peculiarities of the inhabitants of various districts with their history as shown by archæological remains, and with the manners and customs, superstitions and other traditions, comprehended under the convenient expression of Folklore. If your opportunities of observation should enable you, in addition, to fill up any of the schedules relating to these branches of the inquiry, or if you should be in a position to induce friends who have devoted attention to them to furnish the requisite information, the Committee would be much indebted to you for so doing.

The apology the Committee offer for asking assistance from so busy a man as yourself, is that your contributions to the Collective Investigation Committee of the British Medical Association have shown that you are not unwilling to give valuable time to public service of this kind.

I am to state that should you desire to make use of the instruments adopted for these particular measurements, the Committee would be pleased to arrange for the loan to you of a set. Probably, however, those used by you in the ordinary course of your practice would be sufficient for the purpose.

I may add that the Committee think it desirable that any individual measured should also be photographed. The instructions as to photographs have been complained of as somewhat minute; but their object is to permit of the use of the photographs by Mr. Galton's composite method. The Committee will be quite willing, however, to make the best use that can be made of any photographs that do not fully comply with their requirements. If the procuring of photographs should be a matter of expense the Committee would be glad to be informed of it beforehand, and to render any assistance in their power towards meeting it.

If, as the Committee venture to hope, you find yourself able to help them, I shall be obliged by your informing me what number of individuals you think you will be able to observe, in order that the necessary copies of the form may be sent you.

APPENDIX III.

Notes Explanatory of the Schedules.

By E. Sidney Hartland, *F.S.A., Secretary of the Committee.*

The object of the Committee is to obtain a collection of authentic information relative to the population of the British Islands, with a view to determine as far as possible the racial elements of which it is composed. The high interest of the inquiry for all archæologists need not be here insisted on. A satisfactory solution of the problems involved will mean the re-writing of much of our early history; and even if we can only gain a partial insight into the real facts it will enable us to correct or to confirm many of the guesses in which historians have indulged upon data of a very meagre and often delusive character.

The methods it is proposed to adopt have regard to the physical peculiarities of the inhabitants, their mental idiosyncrasies, the material remains of their ancient culture, and their external history. In modern times great movements of population have taken place, the developments of industry and commerce have brought together into large centres natives of all parts of the country, and even foreigners, and thereby caused the mingling of many elements previously disparate. These have enormously complicated the difficulties of the inquiry. They have rendered many districts unsuitable for every purpose except the record of material remains. Scattered up and down the country, however, there are hamlets and retired places where the population has remained stationary and affected but little by the currents that have obliterated their neighbours' landmarks. To such districts as these it is proposed to direct attention. Where families have dwelt in the same village from father to son as far back as their ancestry can be traced, where the modes of life have diverged the least from those of ancient days, where pastoral and agricultural occupations have been the mainstay of a scanty folk from time immemorial, where custom and prejudice and superstition have held men bound in chains which all the restlessness of the nineteenth century has not yet completely severed, there we hope still to find sure traces of the past.

The photographic survey, which has been carried out so well at Birmingham and elsewhere, and has been initiated in our own country, will prove a most valuable aid to the wider work of the Ethnographical Survey. Photographs of the material remains of ancient culture are explicitly asked for in the schedule. In addition to them, photographs of typical inhabitants are urgently desired. Some judgment will, of course, require to be exercised in the selection of types, and a considerable amount of tact in inducing the subjects to allow themselves to be taken. It has been found effective for this purpose, as well as for that of measuring the people, that two persons should go out together, and setting up the camera in the village, or wherever they find a convenient spot, *coram populo*, they should then proceed gravely to measure and photograph one another. This will be found to interest the villagers, and some of them will gradually be persuaded to submit to the operation. A little geniality, and sometimes a more tangible gratification of a trifling character, will hardly ever fail in accomplishing the object. The experience of observers who have taken measurements is that it becomes extremely fascinating work as the collection increases and the results are compared.[1]

This comparison, if the subjects have been selected with judgment, and accurately measured and photographed, should enable us to determine in what proportions the blood of the various races which have from time to time invaded and occupied our soil has been transmitted to the present population of different parts of the United Kingdom. From the ancient remains in barrows and other sepulchral monuments, and from the study of the living peoples of Western Europe, the characteristics of the races in question are known with more or less certainty, and every year adds to our information concerning them. A much more complex problem, and one wherein archæologists have a more direct interest, is how far the culture of the races in question has descended to us, and how far it has been affected by intruding arts, faiths, and inventions. To solve this, appeal is made first to the historic and prehistoric monuments and other material remains, and secondly to the traditions of many kinds that linger among the peasantry. Here the first business, and that with which the practical work of the survey is immediately concerned, is the work of collection. To photograph, sketch, and accurately describe the material remains; to note and report the descriptions and drawings already made, and where they are preserved; to gather and put into handy form the folklore of each country already printed; and to collect from the surviving depositaries of tradition that which may still be found—namely, tales, sayings, customs, medical prescriptions, songs, games, riddles, superstitions, and all those scraps of traditional lore stored in rustic memories, impervious and strange to the newer lore of to-day—these are the necessary preliminaries to the study of the civilisation of our ancestors.

[1] The Ethnographical Survey Committee has a few sets of instruments for taking the measurements, which can be placed temporarily at the disposal of the local committee. Perhaps I may here also express the opinion that if the personal photographs and measurements called for expenditure beyond what could be met by local enthusiasm, the Committee might not be indisposed to contribute by way of a small payment for each photograph and set of measurements.

Archæologists have paid too exclusive attention to the material remains. They have forgotten to inquire what light may be thrown upon them by tradition. By the term tradition I do not mean simply what the people say about the monuments. Antiquaries soon found out that that was always inaccurate, and often utterly false and misleading. Hence thay have been too much inclined to despise all traditions. But tradition in the wide sense of *the whole body of the lore of the uneducated*, their customs as well as their beliefs, their doings as well as their sayings, has proved, when scientifically studied, of the greatest value for the explanation of much that we must fail to understand in the material remains of antiquity. To take a very simple instance: when we find in Gloucestershire barrows, cups, or bowls of rough pottery buried with the dead, we call them food-vessels, because we know that it is the custom among savage and barbarous nations to bury food with the dead and to make offerings at the tomb, and that this custom rests on a persuasion that the dead continue to need food and that they will be propitiated by gifts; and we further infer that the races who buried food-vessels with their dead in this country held a similar opinion. Or, to take another burial custom: General Pitt-Rivers reported last year to the British Association that he had found in excavations at Cranborne Chase bodies buried without the head. If we were ignorant of the practices of other races we should be at a loss to account for such interments. As it is, we ask ourselves whether these bodies are those of strangers whose heads have been sent back to their own land, or their own tribe, in order to be united in one general cemetery with their own people; or whether the heads were cut off and preserved by their immediate relatives and brought into the circle at their festive gatherings to share the periodical solemnities of the clan. Both these are savage modes of dealing with the dead, one of which, indeed, left traces in Roman civilisation at its highest development. The knowledge of them puts us upon inquiry as to other burials of the prehistoric inhabitants of this country, which may help us in reconstructing their worship and their creed. I for one do not despair of recovering, by careful comparison of the relics preserved to us in the ancient monuments with the folklore of the existing peasantry and of races in other parts of the earth, at least the outlines of the beliefs of our remote predecessors.

Any such conclusions, however, must be founded on the essential unity that science has, during the last thirty years, unveiled to us in human thought and human institutions. This unity has disguised itself in forms as diverse as the nationalities of men. And when we have succeeded in piecing together the skeleton of our predecessors' civilisation, material and intellectual, we are confronted by the further inquiries: What were the specific distinctions of their culture? and How was it influenced by those of their neighbours or of their conquerors? This is a question only to be determined, if at all, by the examination of the folklore of the country. We may assume that the physical measurements, descriptions, and portraits of the present inhabitants will establish our relationship to some of the peoples whose remains we find beneath our feet. And it will be reasonable to believe that, though there has been a communication from other peoples of their traditions, yet that the broad foundation of our folklore is derived from our foreathers and predecessors in our own land. In Gloucestershire itself we have strong evidence of the persistence of tradition. Bisley Church is said to have been originally intended to be built several miles off, 'but the Devil every night removed the stones, and the architect was obliged at last to build it where it now stands.' This is, of course, a common tradition. The peculiarity of the case is that at Bisley its meaning has been discovered. The spot where, we are told, 'the church ought to have been built was occupied formerly by a Roman villa;' and when the church was restored some years ago 'portions of the materials of that villa were found embedded in the church walls, including the altars of the Penates, which are now, however, removed to the British Museum.'[1] Here, as Sir John Dorington said, addressing this Society some years ago at Stroud, is a tradition which has been handed down for fifteen or sixteen hundred years. This is in our own country, and it may be thought hard to beat such a record. But at Mold, in Flintshire, there is evidence of a tradition which must have been handed down from the prehistoric iron age—that is to say, for more than two thousand years. A cairn stood there, called the *Bryn-yr-Ellyllon*, the Hill of the Fairies. It was believed to be haunted; a spectre clad in golden armour had been seen to enter it. That this story was current before the mound was opened is a fact beyond dispute. In 1832 the cairn was explored. Three hundred cartloads of stones were removed, and beneath them was found a skeleton 'laid at full length, wearing a corslet of beautifully wrought gold, which had been placed on a lining of bronze.' The corslet in question is of Etruscan workmanship, and is now, I believe, to be seen in the British Museum.[2]

Examples like these—and they stand by no means alone—inspire confidence in the permanence of what seems so fleeting and evanescent. Folklore is, in fact, like pottery, the most delicate, the most fragile of human productions; yet it is precisely these productions which prove more durable than solid and substantial fabrics, and outlast the wreck of empires, a witness to the latest posterity of the culture of earlier and ruder times.

But if these traditions have thus been preserved for centuries and even millenniums, they have been modified—nay, transformed—in the process. It is not the bare fact which has been transmitted from generation to generation, but the fact seen through the distorting medium of the popular imagination. This is a characteristic of all merely oral records of an actual event; and this it is which everywhere renders tradition, taken literally, so untrustworthy, so misleading a witness to fact. The same law, however, does not apply to every species of tradition. Some species fall within the lines of the popular imagination; and it is then not a distorting but a conservative force. The essential identity of so many stories, customs and superstitions throughout the world is a sufficient proof of this, on which I have no space to dwell. But their essential identity is overlaid with external differences due to local surroundings, racial peculiarities, higher or lower planes of civilisation. There is a charming story told in South Wales of a lady who came out of a lake at the foot of one of the Carmarthenshire mountains and married a youth in the neighbourhood, and who afterwards, offended with her husband, quitted his dwelling for ever and returned to her watery abode. In the Shetland Islands the tale

[1] *Gloucestershire N. & Q.* vol. i. p. 390 quoting an article in the *Building News*. See also Sir John Dorington's Presidential Address, *Trans. B. & G. Arch. Soc.* vol. v. p. 7.

[2] Boyd Dawkins, *Early Man in Britain*, p. 431, citing *Archæologia* and *Arch. Cambrensis.*

is told of a seal which cast its skin and appeared as a woman. A man of the Isle of Unst possessed himself of the seal-skin and thus captured and married her. She lived with him until one day she recovered the skin, resumed her seal-shape and plunged into the sea, never more to return. In Croatia the damsel is a wolf whose wolf-skin a soldier steals. In the *Arabian Nights* she is a *jinn* wearing the feather-plumage of a bird, apparently assumed simply for the purpose of flight. In all these cases the variations are produced by causes easily assigned.

The specific distinctions of a nation's culture are not necessarily limited to changes of traditions which it may have borrowed from its neighbours or inherited from a common stock. It may conceivably develop traditions peculiar to itself. This is a subject hardly yet investigated by students of folklore. Their labours have hitherto been chiefly confined to establishing the identity underlying divergent forms of tradition and explaining the meaning of practices and beliefs by comparison of the folklore of distant races at different stages of evolution. But there are not wanting those who are turning their attention to a province as yet unconquered, and indeed almost undiscovered. Even if they only succeed in establishing a negative, if they show that all traditions supposed to be peculiar have counterparts elsewhere, they will have rendered a signal service to science, and produced incontrovertible testimony of the unity of the human mind and the unintermittent force of the laws which govern it.

Alike for the purpose of ascertaining the specific distinctions of culture and the influences of neighbouring nations and neighbouring civilisations, an accumulation of facts is the prime requisite. If we have reason to believe in the persistence of tradition, we shall have confidence that relics will be discovered in our midst of the faith and institutions of our remoter ancestors; and, in accordance as we venerate antiquity or desire to preserve what remains of the past, we shall hasten to collect them. Nor can we be too quick in so doing. The blood of our forefathers is a permanent inheritance, which it would take many generations and a large intermingling of foreigners seriously to dilute, much less to destroy. But tradition is rapidly dying. It is dwindling away before the influences of modern civilisation. Formerly, when the rural districts were isolated, when news travelled slowly and nobody thought of leaving his home save to go to the nearest market, and that not too often, when education did not exist for the peasantry and the landowners had scarcely more than a bowing acquaintance with it, the talk by the fireside on winter evenings was of the business of the day—the tilling, the crops, the kine. Or it was the gossip and small scandals interesting to such a community, or reminiscences by the elders of the past. Thence it would easily glide into tales and superstitions. And we know that these tales and superstitions were, in fact, the staple of conversation among our fathers and generally throughout the West of Europe, to go no further afield, down to a very recent period; and they still are in many districts. In England, however, railways, newspapers, elementary education, politics, and the industrial movements which have developed during the present century have changed the ancient modes of life; and the old traditions are fading out of memory. The generation that held them is fast passing away. The younger generation has never cared to learn them; though, of course, many of the minor superstitions and sayings have still a considerable measure of power, especially in the shape of folk-medicine and prescriptions for luck. We must make haste, therefore, if we desire to add to the scanty information on record concerning English folklore.

As a starting-point for the collection of Gloucestershire folklore I put together, a year or two ago, the folklore in Atkyns, Rudder, and the first four volumes of *Gloucestershire Notes and Queries*; and it was printed by the Folklore Society and issued as a pamphlet.[1] Other works remain to be searched; and it is probable that a good deal more may be found already in print, if some who are interested in the antiquities of the country will undertake the not very arduous, but very necessary, labour of collection. When all is gathered, however, it will only be a small part of what must have existed at no distant date—if not of what still exists, awaiting diligent inquiry among living men and women. How to set about the inquiry is a question that must be left very much to the individual inquirer to answer. Valuable practical hints are given in the *Handbook of Folklore*, a small volume that may be bought for half-a-crown and carried in the pocket. Confidence between the collector and those from whom he is seeking information is the prime necessity. Keep your notebook far in the background, and beware of letting the peasant know the object of your curiosity, or even of allowing him to see that you are curious. Above all, avoid leading questions. If you are looking for tales, tell a tale yourself. Do anything to establish a feeling of friendly sympathy. Never laugh at your friend's superstitions—not even if he laugh at them himself; for he will not open his heart to you if he suspect you of despising them.

There is one other division of the schedule to which I have not yet referred. The Dialect is perishing as rapidly as the folklore; it is being overwhelmed by the same foes. Peculiarities of dialect are due partly to physical, partly to mental, causes. From either point of view they are of interest to the investigator of antiquities. Hence their inclusion among the subjects of the Ethnographical Survey. Nobody who has once understood how much of history is often wrapped up in a single word can fail to perceive the importance of a study of dialect, or how largely it may contribute to the determination of the origin of a given population. The reduction of dialect into writing requires accuracy to distinguish the niceties of pronunciation, and some practice to set them down; but a little experience will overcome most difficulties, which, after all, are not great. It is believed that most of the words—as distinguished from their pronunciation—in use have been recorded in the publications of the English Dialect Society or elsewhere. But it is better to record them again than to leave them unrecorded. Nor should it be forgotten in this connection that a word often bears a different shade of meaning in one place from what it bears in another. In recording any words, care should therefore be taken to seize not only the exact sound, but the exact signification, if it be desired to make a real contribution towards the history of the country, or the history of the language. Of the method of collection and transcription it is needless to add to the directions in the schedule.

[1] *County Folklore. Printed Extracts—No.* 1, *Gloucestershire.* London: D. Nutt, 1892. 1*s.*

The Lake Village at Glastonbury.—Second Report of the Committee, consisting of Dr. R. MUNRO (*Chairman*), Professor W. BOYD DAWKINS, Sir JOHN EVANS, General PITT-RIVERS, *and* Mr. A. BULLEID (*Secretary*). (*Drawn up by the Chairman and the Secretary.*)

I. *Report. By* Dr. R. MUNRO.

THE site of the Lake Village at Glastonbury occupies some three or four acres of a flat meadow, within the boundaries of what is supposed, on good grounds, to have been formerly a lake or marsh. Before excavations were begun all that the eye could discern on the undisturbed surface were sixty or seventy low mounds huddled in the corner of a field. Only about one half of these mounds has as yet been systematically explored, but, so far, the original surmise that each mound formed the site of a hut, resting on a substratum of beams and brushwood, is entirely confirmed. The operations of the last two summers have been largely confined to tracing the village border, which has now been uncovered to the extent of about two-thirds of its circumference. A vast amount of the heterogeneous *débris* of human occupancy has been gathered on and around its site, including five complete skulls and other bones of man. These skulls were found outside the stockaded margin, and it has been remarked that no other bones of the body were associated with them. One of them shows a deep cut, as if made by a sword, and another bears evidence of having been supported on a spearhead, which had been inserted vertically through the first cervical vertebra and the occipital foramen. A full account of the *technique* and purposes of these relics and a list of the flora and fauna collected during the excavations are given in the previous report and in a small guide-book lately published by the Glastonbury Antiquarian Society. Suffice it for the present to say that the relics are of various materials—stone, flint, bronze, iron, bone, horn, glass, pottery, &c. Among the bronze objects are many fibulæ of La Tène forms, spiral finger-rings, penanular brooches, and an elegant bowl. Of bone and horn we have needles, pins, handles, long-handled combs used for wearing, and many other articles. Among the objects of wood are a canoe, the framework of a loom, the staves of buckets, one of which is decorated, part of the axle of a wheel with a couple of spokes in their place. The pottery is very abundant, and often highly ornamented with devices which unmistakably show 'late Celtic' art. Many of the industrial relics exhibit some of the special characteristics of this style of art, the importation of which into Britain preceded, by two or three centuries, the occupation of the island by the Romans; nor does it appear that any of them had been influenced by Roman art. This, indeed, is one of the most interesting features of the Glastonbury find, and this collection of antiquities cannot fail to shed an unexpected light on one of the obscurest periods of British civilisation within prehistoric times. On a previous visit to Glastonbury I observed a leaden weight, shaped like a cheese, having the middle of the rim bulging out. It weighs 4 oz. 229 gr. This is the only metallic article hitherto found of which there may be entertained a suspicion that it had a Roman origin. I understand that Sir Augustus W. Franks has pointed out a piece of pottery recently found which may also have a similar origin. This shows that the village existed as an inhabited place up to Roman times, and it is possible that it was the intrusion of the Romans into this district which put an end to it.

II. *Report on the Work carried on during the Past Year.* *By* Arthur Bulleid.

The digging at the Glastonbury Lake Village was discontinued last year in October, and resumed this season towards the end of April. Since presenting the report of the third year's exploration at the Oxford meeting of the Association, 15 dwelling mounds have been examined, making, with those previously laid open, 30 in all. Besides the 15 dwelling mounds, 500 feet of the palisading, forming the west border of the village, has been traced, together with from 15 to 25 feet of peat adjoining and outside it. This, with the like distance of 500 feet dug in 1893–94, completes the examination of about two-thirds of the total circumference of the village, the remaining unexplored portions of the palisading being situated at the north and south sides. Of the original 65 dwelling mounds there still remain about one-half for future examination, as well as the large spaces of ground between them. The palisading examined this year, bordering the west side of the village, was similar to that exposed in previous years, both with reference to the arrangement of the piles and the irregularity of outline, but it was not so strongly made as that on the east side. At one spot, bordering a space between two dwellings, the palisading was discontinued for 60 feet, and a bank of peat substituted for it; the peat wall was kept in place by a single line of upright piles driven down near its centre, the upper parts of the posts being evidently bound together with hurdle work. During the examination of the dwelling mounds the following structural discoveries were made. With reference to the construction of the floors it was noticed that the clay was covered with planks of split timber, and that the method of arranging the wood varied in different dwellings; in two floors the planks were placed in a circular fashion round the hearth, and parallel to the wall of the house. On another floor the boards were lying diagonally across the dwelling in a south-east and north-west direction. In one dwelling mound four superimposed and complete stone hearths were found, having a layer of clay one foot deep intervening between each. In another dwelling a good door-step was unearthed. The timber foundations of the dwelling mounds recently examined have been found to vary little from those previously explored, with this exception, that one of the small mounds was found to be covering a beam of oak fourteen feet in length, with a mortise-hole near each end, one end lying on and at right angles to a large tree trunk, the two pieces of timber being kept in place by a pile, the upper end of which was found a short distance below the hearth of the dwelling. Other mortised beams were discovered in the vicinity, but it has not been possible as yet to make out their original arrangement, but the one just mentioned, although *in situ*, was evidently not intended, in the first place, for part of the substructure of a dwelling. A number of important objects have been unearthed from the peat outside the village border, as well as from the floors of the dwellings and the ground between them. As during the seasons of 1892, 1893, and 1894, large quantities of hand- and wheel-made pottery, clay sling pellets, and bones of animals have been dug up. Among the things that may be specially mentioned are the following :—

Flint.—A small saw. This was found near the arrow-head mentioned in last year's report.

Stone.—Several circular and saddle-shaped quern stones, and many spindle whorls and whetstones.

Bronze.—More than fifty pieces of bronze, of various descriptions, including one complete mirror, three pairs of tweezers, one bracelet, ten spiral finger and other rings, one pin, two needles, three fibulæ.

Iron.—Among the objects of iron are a spear-head, bill-hook, horse-bit, rings, knives, and a flat piece of the metal more than two feet long, presumably an unfinished sword.

Lead.—Several rings and spindle whorls, or weights.

Bone.—The human remains have been more plentiful than in the previous seasons, and include three complete skulls, fragments of five others, two first cervical vertebræ, one being badly fractured; fragments of bone of a burnt body, the complete skeleton of a very young child, with the exception of the bones of the lower extremities and one arm.

These, with the exception of one bone, were obtained from various parts of the peat outside the village.

The bones of animals and birds found since presenting the last report have not yet been examined.

Worked Bone and Horn.—The objects of cut bone and horn found this season number considerably over a hundred, among them being handles of knives, weaving-combs, needles, haftings, gouges, and a variety of other implements.

Wood.—Some of the more important finds made of wood have been:—Six spokes of a wheel, about 13½ inches long. A complete ladder of four steps, the sides being nearly 7 feet long, made of two split pieces of ash, each side being perforated with four small square mortise-holes for holding the steps. The lowermost step was kept in place by a wooden pin driven through it transversely on the outside. The original top step of wood was missing, but in its place one of plaited withs had been substituted.

A saw-shaped implement of wood, 4 feet long, the greatest width being 2¾ inches, the handle 15 inches in length; along one edge of the blade portion, which tapers to a point, there are a number of saw-like notches, averaging half an inch in depth. This implement was found lying at the side of the ladder in the peat, outside the west border of the village.

Portions of several tubs, buckets, and cups have been dug up; the tubs were, for the most part, stave-made and dovetailed together with wooden pegs; others were cut from the solid. From measurements the fragments show the complete utensils to have ranged from 6 inches to 2 feet 6 inches in height, and from a few inches to two feet in diameter.

A door 3 feet 6 inches high and 16 inches wide, made of one piece of oak, with projections from one edge, above and below, about 4 inches long.

The greater part of a basket, which, when complete, must have been 18 inches high.

Part of a second boat; the fragment is 20 feet long, cut from the solid wood, and belonged to a boat of much greater length. At some places on the inner surface tool-marks and charring were plainly seen.

Many other pieces of wood-work have been found, such as parts of boxes, pegs, pins, and mortised framework.

The botanical, osteological, and geological specimens, recently discovered, have not yet been examined: they will be described in a subsequent report.

The North-Western Tribes of Canada.—Tenth Report of the Committee, consisting of Dr. E. B. TYLOR, Dr. G. M. DAWSON, Mr. R. G. HALIBURTON, *and* Mr. H. HALE, *appointed to investigate the Physical Characters, Languages, and Industrial and Social Conditions of the North-Western Tribes of the Dominion of Canada.*

[PLATE VII.]

CONTENTS.

THE Committee, as was expected last year, are now able to complete their work for the present by sending in the final report, by Dr. Franz Boas, on 'The Indians of British Columbia.'

In concluding the investigations which have since the Montreal Meeting of 1884 been carried on under their direction, the Committee desire to return thanks for the liberality with which the British Association took up the task of preserving records of the Anthropology of the North-Western Tribes of the Dominion of Canada. With equal generosity, the Canadian Government recognised the necessity of the work by large contribution to the funds at the disposal of the Committee. Thus has been brought together a collection of valuable physical and philological information, coupled with accounts of native culture, much of which would probably have changed or disappeared within a few years had not this timely enterprise been undertaken.

For convenience of reference, the principal contributions embodied in the Committee's series of Reports are here set down, viz.:—

Circular of Inquiry drawn up by Committee. (Report III.)

Report on the Blackfoot Tribes, by Mr. Horatio Hale, in correspondence with Father Lacombe and Rev. John McLean. (Report I.)

Report on the Blackfoot Tribes, by Rev. Edward F. Wilson, and Notes by Mr. Hale. (Report III.)

Notes on Indians of British Columbia, by Dr. Franz Boas. (Report IV.)

Report on the Sarcee Indians, by Rev. Edward F. Wilson, and Notes by Mr. Hale. (Report IV.)

Remarks on North American Ethnology, by Mr. Hale. (Report V.)

First Report on the Indians of British Columbia, by Dr. Franz Boas. (Report V.)

Remarks on the Ethnology of British Columbia, by Mr. Hale. (Report VI.)

Second Report on the Indians of British Columbia, by Dr. Franz Boas. (Report VI.)

Introduction, by Sir Daniel Wilson. (Report VII.)

Third Report on the Indians of British Columbia, by Dr. Franz Boas. (Report VII.)

Physical Characteristics of the Tribes of the North Pacific Coast, by Dr. Franz Boas. (Report VII.)

Remarks on Linguistic Ethnology, by Mr. H. Hale. (Report VIII.)

Report on the Kootenay Indians, by Dr. A. F. Chamberlain. (Report VIII.)

Fourth Report on the Indians of British Columbia (Indian Tribes of Lower Fraser River), by Dr. Franz Boas. (Report IX.)

Fifth Report on the Indians of British Columbia, by Dr. Franz Boas. (Report X.)

Fifth Report on the Indians of British Columbia. *By* FRANZ BOAS.

During the months from September to December 1894, I revisited British Columbia under instructions of the Committee, the object of the journey being to fill, so far as possible, gaps left in previous investigations. I considered four points to be of particular importance: the anthropometry of those portions of the province which were not covered by previous work; an investigation of a Tinneh tribe on the extreme northern part of the coast of which I had heard reports, but which has never been described; a study of the customs of the Hē'iltsuq, and further inquiries in regard to the Tinneh tribe of Nicola Valley which was first described by Dr. G. M. Dawson ('Trans. Royal Soc. Canada,' vol. ix. 1891, sec. ii. p. 23).

On account of lack of time I was unable to visit the Hē'iltsuq, and for the same reason I delegated the work in Nicola Valley to Mr. James Teit, of Spence's Bridge, who is thoroughly conversant with the language and the customs of the Ntlakyā'pamuQ. His report will be found embodied in the following pages.

The subject matter which I collected on my journey is presented in the following manner:—

I have to express my obligation for valuable help extended in the course of my work to the Rev. Mr. Collison, of Kinkolith; Mr. George Hunt, of Fort Rupert; Mr. C. O. Hastings, of Victoria, British Columbia; Mr. James Teit, of Spence's Bridge; and Rev. Father Le Jeune, of Kamloops.

The following alphabet has been used in this report:—

The vowels have their Continental sounds, namely: *a* as in *father*; *e* like *a* in *mate*; *i* as in *machine*; *o* as in *note*; *u* as in *rule*.

In addition the following are used: *ä*, *ö* as in German; *â*=*aw* in *law*; *ê* as in *tell*; *î* as in *hill*; *ô* as in German *voll*; E=*e* in *flower* (Lepsius's *e̥*).

Among the consonants the following additional letters have been used: *g*·, velar *g*; *k*·, velar *k*; *q*, the German *ch* in *bach*; H, the German *ch* in *ich*; Q, between *q* and H; *c*=*sh* in *shore*; *tl*, an explosive *l*; *dl*, a palatal *l* (dorso-apical); !, increased stress of articulation; ', the mouth assumes the position for the articulation of *u*.

I. Physical Characteristics of the Tribes of the North Pacific Coast.

In the Seventh Report of the Committee I pointed out that the region around Harrison Lake is inhabited by a peculiar type of man, differing considerably from the types found in the neighbourhood. It seemed desirable to investigate the characteristics of the people of the surrounding country, in order to better define the locality inhabited by this type and to discover in what manner the transition between the distinct types of this region takes place. For this purpose I collected anthropometric data in the region lying between Harrison Lake and Thompson River. This country is inhabited by the Ntlakyā′pamuQ, a tribe speaking a Salish language which has developed very slight dialectic differences only. The people of this tribe live in a great many villages which are scattered along Fraser and Thompson Rivers; but the villages are grouped in five subdivisions of the tribe, which are named as follows: the Utā′mk·t, who live between Spuzzum and Keefers; the NtlakyāpamuQ′ō′ē, or real Ntlakyā′pamuQ, whose territory extends from a little above Keefers to a point above Thompson Siding on Thompson River, and about twenty miles up Fraser River from Lytton; the Nkamtcī′nEmuQ, from Thompson Siding to Ashcroft on Thompson River; StlaQā′yuQ, on the upper part of Fraser River, between the Lillooet and the NtlakyāpamuQ′ō′ē; and finally, the Cawā′QamuQ, of Nicola Valley. For the purpose of my investigation I kept these divisions separate.

Furthermore, the anthropometric material given in the Seventh Report of the Committee was very insufficient so far as the northern parts of the coast are concerned. For the purpose of filling this gap I collected data among the Nass River Indians and among the Kwakiutl. The technique of the measurements was the same as that described in the Seventh Report of the Committee. I have added to the material which I collected for the Committee other data which were collected under my direction for the Anthropological Department of the World's Columbian Exposition; but I have refrained from the use of the head measurements which were gathered at that time, as these would extend the scope of the Report beyond desirable limits.

A glance at the tables (p. 544) will show that a very material change of type takes place somewhere between Vancouver Island and Skeena River. For this reason it is necessary to compare the various Kwakiutl tribes among each other before combining them, in order to see if there is any appreciable difference between them. According to their location, I have combined the material which I collected in the following manner: First, tribes of the Nak'oartôk group, embracing the Goasila and Nak'oartôk; second, tribes of the Koskimo group, embracing the extreme northern tribes of the Nootka, the Kwakiutl tribes of the west coast of Vancouver Island, of Cape Scott and Newettee; third, the Kwakiutl group, embracing the Kwakiutl proper and all the tribes of this group south-east of Fort Rupert.

The following tables show the results of this comparison :—

Kwakiutl.

STATURE OF MEN (20–59 years of age).

Mm.	1560–1579	1580–1599	1600–1619	1620–1639	1640–1659	1660–1679	1680–1699	1700–1719	1720–1739	1740–1759	Average	Number of Cases
Nak'oartôk	—	1	1	1	1	1	—	1	2	—	1662	8
Kwakiutl	2	2	—	1	3	2	1	1	—	1	1641	13
Koskimo	—	5	2	4	3	1	1	2	—	1	1637	19
Total	2	8	3	6	7	4	2	4	2	2	1644	40

STATURE OF WOMEN (17–59 years of age).

Mm.	1460–1479	1480–1499	1500–1519	1520–1539	1540–1559	1560–1579	1580–1599	1600–1619	1620–1639	Average	Number of Cases
Nak'oartôk	—	1	1	3	—	1	—	1	—	1534	7
Kwakiutl	1	2	3	—	1	1	—	—	1	1523	9
Koskimo	—	2	2	2	4	3	4	2	1	1545	20
Total	1	5	6	5	5	5	4	3	2	1537	36

BREADTH OF FACE OF MEN (20 years and over).

Mm.	138 139	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	Average	Number of Cases
Nak'oartôk	—	—	—	—	—	1	2	2	—	3	1	—	1	154·6	10
Kwakiutl	1	1	—	1	4	2	3	2	—	1	—	—	—	147·9	15
Koskimo	—	—	—	5	4	3	2	5	1	—	3	1	—	150·3	24
Total	1	1	—	6	8	6	7	9	1	4	4	1	1	150·4	49

BREADTH OF FACE OF WOMEN (17 years and over).

Mm.	132 133	134 135	136 137	138 139	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	Average	Number of Cases
Nak'oartôk	—	—	—	—	2	—	1	2	2	1	—	—	1	146·7	9
Kwakiutl	—	1	—	2	1	1	2	1	1	1	—	—	—	143·4	10
Koskimo	1	2	1	2	3	3	5	5	—	—	—	—	—	141·8	22
Total	1	3	1	4	6	4	8	8	3	2	—	—	1	143·1	41

HEIGHT OF FACE OF MEN (20–59 years of age).

Mm.	116 117	118 119	120 121	122 123	124 125	126 127	128 129	130 131	132 133	134 135	136 137	138 139	140 141	Average	Number of Cases
Nak'oartôk	—	—	—	1	1	2	—	—	—	2	1	—	2	131·7	9
Kwakiutl	2	—	1	—	1	2	1	2	2	1	1	—	1	128·4	14
Koskimo	—	1	1	—	2	4	4	4	2	1	1	—	—	128·4	20
Total	2	1	2	1	4	8	5	6	4	4	3	—	3	129·1	43

HEIGHT OF FACE OF WOMEN (17–59 years of age).

Mm.	106 107	108 109	110 111	112 113	114 115	116 117	118 119	120 121	122 123	124 125	126 127	128 129	130 131	132 133	134 135	136 137	138 139	Average	Number of Cases
Nak'oartôk	—	—	1	—	—	1	—	—	2	—	1	2	—	—	1	—	—	123·8	8
Kwakiutl	—	—	1	—	2	1	1	1	1	—	1	1	—	—	—	—	—	119·2	9
Koskimo	1	—	—	1	1	2	3	3	1	1	—	3	3	—	—	—	1	122·1	20
Total	1	—	2	1	3	4	4	4	4	1	2	6	3	—	1	—	1	121·8	37

BREADTH OF NOSE OF MEN (20–59 years of age).

Mm.	35	36	37	38	39	40	41	42	43	44	45	46	Average	Number of Cases
Nak'oartôk	—	—	—	1	2	1	1	2	—	1	—	—	40·6	8
Kwakiutl	4	1	2	2	1	1	—	—	3	—	—	—	38·1	14
Koskimo	—	1	1	5	5	4	—	3	—	—	—	1	39·5	20
Total	4	2	3	8	8	6	1	5	3	1	—	1	39·3	42

BREADTH OF NOSE OF WOMEN (17–59 years of age).

Mm.	30	31	32	33	34	35	36	37	38	39	Average	Number of Cases
Nak'oartôk	—	1	—	—	—	2	—	2	1	1	35·0	7
Kwakiutl	1	1	1	1	—	3	1	—	1	—	33·9	9
Koskimo	—	1	1	2	2	6	1	3	1	3	35·4	20
Total	1	3	2	3	2	11	2	5	3	4	35·2	36

HEIGHT OF NOSE OF MEN (20–59 years of age).

Mm.	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	Average	Number of Cases
Nak'oartôk	—	—	—	—	1	—	1	1	—	4	—	—	—	1	—	1	57·0	9
Kwakiutl	1	—	—	1	2	1	1	1	2	2	2	—	1	—	—	—	54·8	14
Koskimo	1	—	—	1	2	1	1	2	1	4	4	2	1	—	—	—	55·7	20
Total	2	—	—	2	5	2	3	4	3	10	6	2	2	1	—	1	55·7	43

HEIGHT OF NOSE OF WOMEN (17–59 years of age).

Mm.	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Average	Number of Cases
Nak'oartôk	—	1	—	—	1	—	—	—	1	1	—	1	—	1	—	1	—	—	—	—	—	—	—	—	51·7	7
Kwakiutl	1	1	2	1	1	—	—	—	—	1	—	—	—	—	1	—	—	1	—	—	—	—	—	—	48·8	9
Koskimo	—	—	—	—	2	1	1	3	—	2	3	3	—	1	1	1	—	1	—	—	—	—	—	1	53·1	20
Total	1	2	2	1	4	1	1	3	1	4	3	4	—	2	2	2	—	2	—	—	—	—	—	1	51·8	36

It appears that the three groups are quite uniform. Possibly the breadth of face of the most northern group, the Nak'oartôk, is a little larger than that of the others, but the number of cases is so small that it remains doubtful if there is any real difference between the types. It will be seen that the three tribes differ very considerably from the Nass River Indians, their faces being much higher and narrower.

In order to prove properly the uniformity of the material collected among the Kwakiutl, it is necessary to take into consideration their habit of deforming the head by means of a pressure brought to bear upon the front and sides of the head. Possibly the practice might have an effect upon the development of the face, which differs much from the form found among all the neighbouring tribes. In order to decide if the artificial deformation has any influence upon the form of the face, I have divided the material into three groups:—Heads not deformed or slightly deformed only, moderately deformed heads, and strongly deformed heads. As will be seen from the tables showing the measurements of individuals, I made finer distinctions when recording the original observations, namely:—Not deformed, slightly deformed, moderately deformed, considerably deformed, strongly deformed, and very strongly deformed. The first two classes embrace children and young persons only, the practice of deformation being gradually abandoned. Leaving these out of consideration, we find the following numbers of individuals in each class:—

—	Men	Women	Men	Women
Moderately deformed .	25	9	59 %	32 %
Considerably deformed .	8	7	19 %	25 %
Strongly deformed . .	9	9	22 %	32 %
Very strongly deformed .	—	3	—	11 %

This table shows that the heads of female children were much more strongly deformed than those of male children, and that the deformation represented in each group is stronger among women than among men.

—		Slightly Deformed	Moderately Deformed	Much Deformed
Length of Head	Men . .	191·6	196·7	195·6
	Women . .	186·3	187·4	191·2
Breadth of Head	Men . .	158·7	160·3	153·6
	Women . .	153·4	154·0	147·0
Breadth of Face	Men . .	146·3	151·6	150·7
	Women . .	143·2	143·4	143·1
Height of Face	Men . .	128·4	130·1	129·2
	Women . .	118·6	119·7	123·6

The differences exhibited in this table show clearly that a strong deformation of the kind practised by the Kwakiutl increases the length of head and diminishes the breadth of head; but that moderate degrees of deformation do not influence materially the lower portion of the skull, in which the greatest breadth of the head is found. The table does not reveal any influence upon the dimensions of the face, so that, so far as the latter is concerned, we may consider all the measured individuals together, without regard to the degree of deformation of the head.

While the preceding discussion has shown that the tribes of the

33	34	35	36	37	38	39	40	41	42
Charles Russ	Thomas Trounce	Luke Nelson K·aqs	William Pollard	Moses Bell	Charles Woods	Matthew Haldane	Heber Watson	Chief Mountain	Philip Latimer
F. Tsimshian M. Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Gyitkca'n	Nisk·a'	Tsimshian
38	40	45	55	58	60	62	65	67	65–70
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
717	1,677	1,625	1,644	1,645	1,627	1,623	1,633[10]	1,573[11]	—[12]
435	1,373	1,328	1,333	1,332	1,371	1,342	1,331	1,282	—
808	774	745	756	728	779	762	718	720	—
860	1,798	1,730	1,761	1,740	1,810	1,735	1,685	1,647	—
888	911	904	890	915	840	865	900	846	795
415	385	378	402	373	400	418	400	388	357
197	195	205	204	206	194	197	199	191	194
161	159·5	158	164	162	158	163	160	161	169
109	119	119	124	123	128	125	120	124	113
165	158	152·5	159	149	161	167	155	156	158
52	57	50	53	52	51	52	54	49	53
40	41	39	46	42	47	49	43	41	41
1·7	81·8	77·1	80·4	78·6	81·4	82·7	80·4	84·3	87·1
6·1	75·3	78·0	78·0	82·6	79·5	74·9	77·4	79·5	71·5
76·9	71·9	78·0	86·8	80·8	92·2	94·2	79·6	83·7	77·4
7·0	46·1	45·7	46·1	44·1	47·8	47·0	44·0	45·9	—
8·1	107·0	106·1	107·4	105·5	111·1	107·1	103·4	104·9	—
51·6	54·2	55·5	54·3	55·5	51·5	53·4	55·2	53·9	—
24·1	22·9	23·2	24·5	22·6	24·5	25·8	24·5	24·7	—

on of gunpowder. [8] Son of No 41. Right leg broken.

1. Ts'ets'â'ut — Males. 2. Nisk'a' — I. Males.

	1. Ts'ets'â'ut			2. Nisk'a'											
Number	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12
Name	Jonathan Dangell	Timothy	Levi	James Stewart	Charlie Ward	Philip Latimer	Arthur Nelson	Matthew Forster	John McNeill	Perry Barton	Gasper Ross	Andrew Nelson	Matthew Gurney	Mac Kycbo'	John Green
Tribe	Ts'ets'â'ut	Ts'ets'â'ut	Ts'ets'â'ut	Nisk'a'	Nisk'a'	F. Tsimshian (No. 1..), M. Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	F. Nisk'a', M. Gyitkca'n	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'
Age	14	21	55	6	6	9	10	10	10	11	13	14	14	14	15
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height standing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,421	[illegible]	[illegible]	[illegible]	[illegible]
Height of shoulder	1,322	—	1,303	880	[illegible]	917	1,023	1,107	1,021	1,010	1,141	1,206	1,285	1,250	1,305
Length of arm	678	—	718	495	466	527	559	561	584	619	63[illegible]	649	715	683	700
Finger-reach	1,554		1,602	1,168	1,102	1,208	[illegible]	1,351	1,334	1,[illegible]00	1,168	1,535	1,654	1,640	1,647
Height, sitting	[illegible]	—	861	640	706	[illegible]	720	705	[illegible]	714	787	790	876	867	882
Width of shoulder	354	—	352	238	238	274	275	272 (?)	[illegible]	289	306	328	348	412	[illegible]
Length of head	190	191	183	172	179	173	184	178	184	174	178	188	186	180	184
Breadth of head	158	153	1[illegible]7	140	144	151	151	156	147	155	144	162.5	159	161	157.5
Height of face	116	128	1[illegible]2	[illegible]	[illegible]	[illegible]	10[illegible]	[illegible]	105	99	100	110	11[illegible]	11[illegible]	121
Breadth of face	146	146	151	120	123.5	128	11[illegible]	[illegible]	135	135	134	139	143	145	146.5
Height of nose	47	50	56	34	37	[illegible]	[illegible]	43	46	39	38	43	46	47	48
Breadth of nose	41	41	47	30	30.5	31	34	34	34	35	44	38	40	37	41
Length-breadth index	[illegible]	[illegible]	[illegible]	81.4	80.4	87.3	82.1	87.1	79.[illegible]	89.1	80.9	81.2	[illegible]	[illegible]	87.1
Facial index	75.3	87.7	80.8	76.7	75.3	74.2	77.5	75.6	77.8	73.4	74.7	73.7	78.3	77.3	82.6
Nasal index	87.2	82.0	70.8	88.2	82.4	81.8	84.6	81.1	73.9	89.7	89.5	88.4	87.0	78.7	85.4
Index of arm	42.4	—	46.7	43.9	43.4	43.6	44.1	41.8	45.4	41.6	44.8	43.6	45.3	44.4	42.9
Index of finger-reach	99.4	—	105.9	103.6	102.6	100.0	102.6	98.8	103.4	98.5	103.4	103.0	104.4	106.5	101.1
Index of height, sitting	54.2	—	51.8	56.8	55.5	55.4	56.7	52.4	53.6	54.1	53.8	53.0	54.2	52.4	54.1
Index of width of shoulders	21.9	—	22.4	21.1	22.1	21.0	21.7	20.2 (?)	20.3	21.9	21.5	22.0	22.0	22.2	22.3

	2. Nisk'a'														
Number	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Name	Harry Forster	Stephen Barton	Willy Bailey	James Ward	Peter Stafford	Peter Watson	Charles Tait	William Sutton	James K'wapsê'	Albert Allan	Josiah Wilson	John Edwards	John Tait	John Wesley	Walter Haldane
Tribe	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	F. Gyitkca'n, M. Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	F. Nisk'a', M. Gyitkca'n	Nisk'a'	F. Tsimshian, M. Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'
Age	16	16	16	17	17	20	20	20	25	27	28	28	[illegible]	[illegible]	33
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height standing	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,671	1,723	[illegible]	1,771	1,7[illegible]	[illegible]	[illegible]
Height of shoulder	1,346	1,274	1,308	1,304	1,350	1,410	1,352	1,293	1,373	1,434	1,327	1,460	1,423	—	1,397
Length of arm	719	617	716	761	73[illegible]	664	725	719	750	610	729	850	653		784
Finger-reach	1,724	1,554	1,694	1,766	1,734	1,650	1,691	1,734	[illegible]593	1,850	1,712	1,830	1,808	—	1,841
Height, sitting	869	850	900	914	895	890	908	828	1,816	928	877	942	878	880	964
Width of shoulder	396	378	379	390	384	376	355	402	678	387	378	365	381	393	396
Length of head	188	188	189	192	186	187	191	189	190	203	186	204	194	192.5	189
Breadth of head	154	153	158	161.5	157	157	160	155	166	164	161	160	157	164	165
Height of face	1[illegible]	12[illegible]	12[illegible]	119	119	123	112	124	12[illegible]	120	119	133	124	126	110
Breadth of face	151	146	148	149	149	142	150	143	155	160	146	157.5	157	160	163
Height of nose	46	50	5[illegible]	50	51	48	48	47	52	48	49	53	49	49	49
Breadth of nose	37	39	37	41	40	43	38	35	37	42	41	43	39	37	39
Length-breadth index	[illegible]	81.6	83.6	80.5	84.1	84.0	[illegible]	81.6	87.4	80.8	81.2	78.4	[illegible]	[illegible]	[illegible]
Facial index	78.8	84.6	83.1	79.9	79.9	86.6	74.7	86.7	77.4	75.0	80.4	84.4	79.0	78.8	67.5
Nasal index	82.2	78.0	74.0	82.0	74.1	89.6	79.2	74.5	71.2	87.5	83.7	81.1	70.6	75.5	79.6
Index of arm	45.3	44.4	43.0	45.6	45.1	43.1	44.8	44.4	46.7	47.1	44.7	45.2	46.3	—	45.8
Index of finger-reach	105.8	101.5	103.9	105.7	105.7	104.8	104.4	107.1	108.7	107.6	105.0	103.4	106.4	—	107.7
Index of height, sitting	53.3	54.1	55.2	54.7	54.6	55.3	56.0	51.1	52.6	54.0	53.8	53.2	51.6	52.4	55.8
Index of width of shoulders	24.3	24.1	23.3	23.4	23.4	23.3	24.1	24.8	23.1	22.5	23.2	21.8	22.4	23.4	23.2

	2. Nisk'a'														
Number	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Name	Frank Gurney	Stephen Allen	Alfred Watson	Abel	George Latimer	Charles Ross	Thomas Trounce	Luke Nelson K'waps	William Pollard	Moses Reid	Charles Woods	Matthew Haldane	Heber Watson	Alfred Mountain	Philip Latimer
Tribe	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	F. Tsimshian, M. Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Nisk'a'	Gyitkca'n	Nisk'a'	Tsimshian
Age	35	35	35	[illegible]	37	38	40	45	45	58	60	[illegible]	65	67	65–70
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Height standing	1,642	1,726	1,698	[illegible]	1,640	1,717	677	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Height of shoulder	1,335	1,440	1,340	1,381	1,350	1,415	1,373	1,328	1,433	1,332	1,371	1,342	1,3[illegible]1	1,282	—
Length of arm	751	784	729	780	742	808	774	71[illegible]	7[illegible]	[illegible]58	77[illegible]	70[illegible]	718	720	
Finger-reach	1,723	1,850	1,827	1,603	1,741	1,860	1,708	1,730	1,7[illegible]1	1,710	1,810	[illegible]	[illegible]	1,617	
Height, sitting	902	931	881	878	893	868	911	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7[illegible]5
Width of shoulder	425	385	385	393	408	415	38[illegible]	[illegible]78	[illegible]	[illegible]	400	[illegible]	400	[illegible]88	377
Length of head	198	192	196.5	194	200	197	195	205	204	[illegible]07	191	197	19[illegible]	191	194
Breadth of head	167	157	166	163	167	161	159.5	158	164	162	158	16[illegible]	164	161	169
Height of face	111	123	127	116	127	10[illegible]	11[illegible]	119	121	124	128	12[illegible]	120	124	113
Breadth of face	164	160	166.5	161	165.5	165	158	152.5	169	14[illegible]	161	1[illegible]7	15[illegible]	176	178
Height of nose	50	52	54	53	52	53	57	50	53	52	51	52	54	49	53
Breadth of nose	42	43	41	42	38	40	41	39	46	42	47	4[illegible]	43	41	41
Length-breadth index	84.3	81.8	84.5	84.1	81.5	81.7	81.8	77.1	80.4	78.6	81.4	8[illegible]7	8[illegible]4	84.3	87.1
Facial index	67.7	82.0	81.2	72.1	76.8	66.1	75.3	78.0	78.0	82.6	79.5	74.[illegible]	77.4	79.5	71.5
Nasal index	84.0	82.7	75.9	79.2	73.1	76.9	71.9	78.0	86.8	80.8	92.2	84.2	73.6	83.7	77.4
Index of arm	46.1	45.3	42.9	46.7	45.2	47.0	46.1	45.7	46.1	44.1	47.8	47.0	44.0	45.9	—
Index of finger-reach	105.7	105.8	107.3	108.0	106.2	108.1	107.0	106.1	107.4	105.5	111.1	107.1	103.4	104.0	—
Index of height, sitting	55.3	53.8	51.8	52.6	54.5	51.6	54.2	55.5	54.3	55.5	51.5	53.4	55.2	53.9	—
Index of width of shoulders	26.1	22.3	22.6	23.9	24.9	24.1	22.9	23.2	24.5	22.6	24.5	25.8	24.5	24.7	—

[1] Son of Nos. 42 and 70. Brother of No. 49. [2] Son of No. 67. Brother of Nos. 9, 44, 55. [3] Brother of No. 13. [4] Son of No. 67. Brother of Nos. 4, 44, 55. [5] Son of No. 28. [6] Brother of No. 5. [7] Son of Nos. 40 and 74. Blind in consequence of an explosion of gunpowder. [8] Son of No. 41. Right leg broken. [9] Father of No. 10. [10] Father of No. 18. Occiput rather flat. Large exostosis on vertex. [11] Father of No. 26. [12] Father of Nos. 3 and 49. Much bent by age.

nued).

2A. *Nisk·a' Half-bloods.*

		I. Males.				II. Females.		
58		75	76	77	78	79	80	81
Susan Allen		Dick Woods	William Elliot	Frank Days	Charles Elliot	Dorothea Alice Elliot	Sarah Ward	Emma Allen
F. Nisk·a' M. Gyitkca'n		F. American M. ½ Nisk·a', ½ White	F. ½ Nisk·a', ½ Dutch M. Nisk·a'	F. Spaniard M. Nisk·a'	F. Scotch M. Nisk·a'	F. ½ Nisk·a', ½ Dutch M. Nisk·a'	F. White M. Nisk·a'	F. Scotch M. Tsimshian
20		3	5	16	29	6	25	32
mm. 1,571	m 1,	mm. 888	mm. —[30]	mm. 1,579	mm. 1,652	mm. 1,146[31]	mm. 1,632	mm. 1,603
1,283	1,	—	—	1,301	1,352	888	1,360	1,312
679		—	—	726	754	465	732	723
1,605	1,	898	—	1,630	1,712	1,118	1,686	1,653
862		504	—	834	872	635	822	874
318		201	—	326	374	243	326	328
193·5		168	176	179	188	175	176	181
150		141	140	151·5	150	145	160	155
115		90	—	111	130	95	117	110
142·5		112	117	140·5	144	119	139	146
47		34	39	49	55	37	52	48
38		26	28	38	35	32	31	33
77·5		83·9	79·6	84·7	79·8	82·9	90·9	85·6
80·9		80·4	—	78·9	90·3	79·8	84·2	75·4
80·9		76·5	71·8	77·6	63·6	86·5	59·6	68·8
43·2		—	—	45·9	45·7	40·4	44·9	45·2
102·2	1	101·1	—	103·2	103·8	97·2	103·4	103·3
54·9		56·8	—	52·8	52·8	55·3	50·4	54·6
20·3		22·6	—	20·6	22·7	21·1	20·0	20·5

. 51. k. [23] Daughter of No. 67. Sister of Nos. 4, 9, and 44.

Nos. 4, 9, 44 No. 62. Sister of No. 76.

2. Nisk·a' (continued).

II. Females.

	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
Name	[illegible]	Elizabeth Nelson	Ellen Barton	[illegible]	Josephine Ward	Emily Barton	Mary [illegible]	[illegible]	[illegible] Ward	[illegible] Woods	Fanny [illegible]	Jane Harvey	Julia Sutton	Bessie Seymour	Margaret Watson	[illegible]	Nellie Seymour	Esther [illegible]	Mary Edwards	[illegible]
Tribe	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a' (Upper part of river)	Nisk·a'	Nisk·a'	F. Tsimshian, M. Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	F. Nisk·a', M. [illegible]	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'
	2	5	[illegible]	7	[illegible]	9	11	12	12	16	[illegible]	17	8	[illegible]	20	[illegible]	22	25	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]	1,137	1,225	[illegible]	1,357	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,594	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
		[illegible]	[illegible]		922	[illegible]	[illegible]	[illegible]	1,178	1,285		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,271	[illegible]	[illegible]	[illegible]
		419	456	—	485	538	556	[illegible]	626	680	—	732	716	702	726	679	688	601	687	678
	917	1,003	1,050	—	1,124	1,255	1,430	1,340	1,510	1,582	—	1,452	1,665	1,650	1,643	1,605	1,613	1,570	1,612	1,628
	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	757	738	[illegible]	–	[illegible]	[illegible]	[illegible]	812	802	[illegible]	[illegible]	[illegible]	[illegible]
	—	235	241	274	241	263	[illegible]	294	313	310	—	295	352	374	349	318	343	353	318	358
Length of head	168	170	177	173	167	170	176	178·5	176	181	181	181	194	197	184	193·5	185	179	181	185·5
Breadth of head	144	137	149	142	144	148	151	145	146·5	151	149	145	153	156·5	157	150	158·5	156	154·5	157
Height of face	85	89	94	92	97	97	101	98	109	112	—	105	111	117	118	115	113	114	110	108
Breadth of face	123	118	120	123	123	125	134	130	129	138	130	133·5	143	149	144	142·5	144·5	147	144·5	148·5
Height of nose	32	36	38	37	37	40	39	40	44	44	—	42	47	43	46	47	45	45	[illegible]	48
Breadth of nose	28	29	29	30	33	31	31	34	36	34	—	37	35	38	38	38	35	33	38	37
Cephalic index	85·7	80·6	83·6	82·4	86·2	85·3	85·8	81·2	83·2	82·5	81·0	80·1	79·3	79·4	85·3	77·5	85·7	87·2	85·4	84·7
Facial index	69·1	75·5	78·3	74·8	78·9	77·6	75·4	76·2	84·5	81·2	—	76·6	77·6	78·5	81·9	80·0	78·2	77·0	76·2	72·8
Nasal index	87·5	80·5	76·3	81·1	89·2	77·5	79·5	85·0	81·8	77·3	—	88·1	74·5	88·4	73·3	80·9	77·8	73·3	102·7	77·1
Index of arm	-	41·9	[illegible]		42·5	44·1	42·0	39·8	42·6	44·2		—	[illegible]	45·0	45·7	44·2	44·4	42·9	43·8	44·0
Index of finger-reach	99·1	100·3	98·1	—	98·0	102·7	100·8	96·4	102·8	101·4	—	—	104·0	107·7	103·3	102·9	104·1	102·0	102·7	105·7
Index of height, sitting	58·0	55·6	56·6	—	56·8	56·8	54·4	54·5	50·2	53·1	—	—	51·8	54·7	53·0	51·9	55·4	56·0	54·1	54·7
Index of width of shoulders	—	23·5	22·5	—	21·1	21·6	21·1	21·1	21·3	20·4	—	—	22·1	24·0	23·0	20·3	22·1	22·9	22·2	23·2

2A. Nisk·a' Half-blood.

(Columns 75–78: I. Males. Columns 79–81: II. Females.)

	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
Name	Emily [illegible]	Amy Watson	[illegible]	[illegible] Barton	Annie Nelson	[illegible]	Emma Ward	Maria Latimer	Louisa [illegible]	Maria Woods	[illegible]	[illegible] Watson	[illegible]	William [illegible]	[illegible]	[illegible]	Dorothy [illegible]	[illegible]	Emma [illegible]
Tribe	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	Nisk·a'	F. [illegible], M. Nisk·a'	F. Nisk·a', [illegible], M. Nisk·a'	F. [illegible], M. Nisk·a'	F. Scotch, M. Nisk·a'	F. Nisk·a', [illegible], M. Nisk·a'	F. White, M. Nisk·a'	F. [illegible], M. Tsimshian
	[illegible]	[illegible]	[illegible]	2	5	[illegible]	40	[illegible]	[illegible]	[illegible]	[illegible]	1			[illegible]	[illegible]	[illegible]	[illegible]	2
	[illegible]	[illegible]	[illegible]	[illegible]	1,512	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	1,276	[illegible]	1,230	[illegible]	1,210	[illegible]	1,245	1,280	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	713	642	[illegible]	665	679	673	662	683	685	657	701	680			726	754	[illegible]	732	[illegible]
	1,656	1,198	1,653	1,580	1,675	1,567	1,535	1,567	1,618	1,570	1,620	1,608	868		1,630	1,712	1,118	1,686	[illegible]
	[illegible]	[illegible]	850	878	[illegible]	811	828	811	[illegible]		[illegible]	827	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	334	354	370	342	323	352	[illegible]	355	354		360	331	[illegible]		[illegible]	374	243	326	328
Length of head	188	183·5	188	186	180	183	182	186	191	192	186	181	168	176	179	188	175	176	181
Breadth of head	154·5	156	156	147·5	161	158	140	144	155	163·5	151	155	141	140	[illegible]	150	145	160	155
Height of face	119	109	117	111	105	121	106	114	117	125	117	117	90	—	111	130	95	117	110
Breadth of face	142	141	149	142	143	146	142	137	149	152	147	141	112	117	140·5	144	119	[illegible]	146
Height of nose	48	40	46	45	42	49	42	43	45	59	53	44	34	30	49	55	37	52	45
Breadth of nose	35	35	39	41	39	38	39	33	37	36	38	39	26	28	38	35	32	31	33
Cephalic index	82·2	85·0	83·0	79·3	81·2	86·3	81·9	77·4	81·2	85·2	81·2	85·6	83·9	79·6	84·7	79·8	82·9	90·9	85·6
Facial index	83·8	76·2	78·5	78·2	73·4	82·9	71·7	83·2	78·5	82·2	79·6	83·0	80·4	—	78·9	90·3	79·8	84·2	77·4
Nasal index	72·9	87·5	84·8	91·1	92·0	77·6	92·9	76·7	82·2	59·4	71·7	88·6	76·5	71·8	77·6	63·6	86·5	59·6	68·8
Index of arm	45·7	44·1	45·7	[illegible]	45·0	44·3	44·1	44·4	45·1	42·7	[illegible]	43·9		-	45·9	45·7	40·4	41·9	45·2
Index of finger-reach	106·2	100·5	106·6	102·6	104·3	103·1	102·9	101·8	106·4	101·9	103·2	102·4	101·1	—	[illegible]	103·8	97·2	104·4	103·3
Index of height, sitting	55·0	56·1	54·8	57·0	54·0	55·5	55·2	51·5	53·0	—	52·4	52·7	56·8	—	52·6	52·8	55·3	50·4	54·6
Index of width of shoulders	21·4	23·8	23·9	22·2	21·4	23·2	23·3	21·6	23·3	—	22·9	21·1	22·6	—	20·6	22·7	21·1	20·0	20·8

[43] Daughter of No. 65. [44] Daughter of No. 67. Sister of Nos. 4, 9, 55. [44] Mother of halfbreeds Nos. 76 and 79. [51] Daughter of No. 63. Sister of No. 48. [52] Mother of Nos. 45 and 48. [53] Hunchback. [54] Mother of No. 43. [55] Sister of No. 51. [57] Mother of Nos. 4, 9, 44, and 55. [58] Daughter of No. 63. Sister of No. 48. [59] Mother of Nos. 3 and 49. [60] Daughter of Nos. 42 and 70. [61] Mother of No. 18. [62] Son of No. 62. Brother of No. 79. Consumptive. [63] Sister of No. 47. [64] Idiotic. [65] Hunchback. [65] Daughter of No. 62. [66] Daughter of No. 67. Sister of Nos. 4, 9, and 44. Sister of No. 76.

4. *Hēiltsuk.*

	II. Females							Female
7	18	19	20	21	22	23	24	1
...ha mtsit	Tlā'tlemēgyila	Ts'ō'qtsaētsEnk·a	TsEk·ā'tla	ME'lnētsas	K·'ē'k·'aqtlala	K·'ā'k'oēgyi'lak'	Ma'qmalak'udayuk·oa	A'lakyilauk·oa
M. Awī'ky'enôx	Nak'oartôk	Goasila	F. Kwakiutl M. Nak'oartôk	Nak'oartôk	Nak'oartôk	Goasila	Nak'oartôk	F. Hēiltsuk· M. Awī'ky'ēnôq
5	28	30	50	50	60	60	65	58
m.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
08[15]	1,486	1,565[16]	1,597	1,522[17]	1,532	1,542[18]	1,530[20]	1,522[21]
28	1,197	1,273	1,322	1,243	1,236	1,250	1,272	1,255
66	626	650	676	694	680	658	668	675
83	1,525	1,615	1,645	1,650	1,660	1,635	1,570	1,618
84	853	841	842	840	863	810	835	826
33	345	342	370	357	358	338	342	335
81[5]	192[1]	194[4]	190[4]	186[4]	200[3]	181[19]	190[4]	182[19]
51[5]	160[1]	163[4]	156[4]	155[4]	159[3]	171[19]	152[4]	162[19]
26	117	123	123	128	134	129	125	115
40	141·5	150	146	147·5	148	156	148	150
51	47	56	52	54	58	59	57	52
39	35	35	37	38	37	37	36	38
·4[5]	83·3[1]	84·0[4]	82·1[4]	83·3[4]	79·5[3]	94·4[19]	80·0[4]	89·1[19]
·0	83·0	82·0	84·3	87·1	90·5	82·7	84·5	76·7
·5	74·5	62·5	71·2	70·4	63·8	62·7	63·1	73·1
·1	42·0	41·4	42·3	45·7	44·4	42·7	43·7	44·4
·9	102·4	102·9	102·8	108·6	108·5	106·2	102·0	106·5
·5	57·2	53·6	52·6	55·3	56·4	52·6	54·6	54·3
·1	23·2	21·8	23·1	23·5	23·4	22·0	22·4	22·0

uch deformed. [7] Son of No. 12, brother of No. 2. [8] Son
'ather of Nos. 1 and 2; son of Nos. 15 and 23; brother of No. 19.
[17] Sister of No. 8. [18] Grandmother of Nos. 1 and 2, mother

3. Goasila and Nak'oartok. 4. Heiltsuk.

	I. Males																		II. Females						Females
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1
Name	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tribe	F. ½ Goasila ½ Nak'oartok, M. Goasila	F. ½ Goasila, ½ Nak'oartok, M. Goasila	Nak'oartok	[illegible]	Nak'oartok	Nak'oartok	Nak'oartok	[illegible]	[illegible]	[illegible]	[illegible]	F. Nak'oartok, M. [illegible]	Nak'oartok	Nak'oartok	[illegible]	F. Nak'oartok, M. [illegible]	F. Nak'oartok, M. [illegible]	Nak'oartok	Goasila	F. [illegible], M. Nak'oartok	Nak'oartok	Nak'oartok	Goasila	Nak'oartok	F. Heiltsuk, M. [illegible]
Age	[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]			[illegible]	[illegible]		[illegible]	[illegible]	30	[illegible]	50	60	[illegible]	65	58
	mm.	mm.	mm.	mm.	mm.	mm.	mm.							mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]		[illegible]
Height of shoulder	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,272	[illegible]
[illegible]	[illegible]	[illegible]	725	[illegible]	[illegible]	751	778	[illegible]	[illegible]	711	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	676	[illegible]	[illegible]	[illegible]	[illegible]	675
[illegible]	[illegible]	[illegible]	1,715	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	1,615	1,645	[illegible]		[illegible]	1,570	1,618
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	911	910	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			811	[illegible]	[illegible]	[illegible]	[illegible]	845	826
Width of shoulders	[illegible]	371	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	312	370	[illegible]	[illegible]	[illegible]	342	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	147	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	111	[illegible]	121	[illegible]	121	[illegible]	110	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	110	[illegible]	117	[illegible]	123	[illegible]	[illegible]	[illegible]	125	117
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	178	171	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111	[illegible]	[illegible]	150	[illegible]	[illegible]	[illegible]	[illegible]	148	[illegible]
[illegible]	[illegible]	58	[illegible]	56	52	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	42	[illegible]	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]
Length-breadth index	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82.1	[illegible]	[illegible]	[illegible]	80.0	[illegible]
Facial index	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	76.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	84.3	76.7
Nasal index	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63.1	73.1
Index of arm	[illegible]	[illegible]	44.8	46.0	46.0	[illegible]	45.0	[illegible]	41.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	42.3	45.7	44.4	42.7	43.7	44.4
Index of finger reach	100.0	104.8	107.7	111.3	105.2	105.1	101.1		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	106.5
Index of height sitting	[illegible]	56.2	[illegible]	52.8	53.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Index of width of shoulders	22.4	22.8	[illegible]	25.4	22.7	22.3	21.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23.1	23.5	[illegible]	22.0	[illegible]	[illegible]

[1] Not deformed. [2] Slightly deformed. [3] Moderately deformed. [4] Considerably deformed. [5] Much deformed. [6] Very much deformed. [7] Son of No. 12, brother of No. 2. [8] Son of No. 12, brother of No. 1. [9] Brother of No. 6. [10] Brother of No. [illegible]. [11] Brother of No. [illegible]. [12] Grandchild of No. 24. [13] Father of Nos. 1 and 2, son of Nos. 15 and 24, brother of No. 1[illegible]. [14] Grandfather of Nos. 1 and 2, father of No. 12. [15] Daughter of Heiltsuk (No. 1). [16] Daughter of Nos. 15 and 24, sister of No. 12. [17] Sister of No. 8. [18] Grandmother of Nos. 1 and 2, mother of No. 12. [19] Occiput flattened. [20] Grandmother of No. 10. [21] Grandmother of No. 17.

21	22	23	1	42	43	44	45	46	47	48	49
K·'ō'melagyilis	NEmō'kuitsâlis	NEgyī's	[illegible]	K·ē'wilEmk·a	Qā'nusEmēk·a	Ē'HtsEmatōsElagyilis	NEmsqEmsE'las	Quā'nē	Yā'k·amHsayuk·oa	Tl'ā'litl	AnH'anutsE'mk·a
Koskimo	Koskimo	F. Koskimo M. Tlask·'ē'nôq	[illegible]	Gyō'p'ēnôq	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo
50	50	55	0	40	40	40	42	45	50	60	60
mm.	mm.	mm.	m.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
1,593[27]	1,634	1,620	1,94	1,502	1,542	1,543[35]	1,565	1,585[22]	1,530	1,542	1,504[36]
1,324	1,303	1,316	1,17	1,184	1,250	1,261	1,276	1,266	1,243	1,240	1,193
702	727	724	70	576	637	657	661	682	657	663	656
1,755	1,708	1,745	1,10	1,432	1,540	1,645	1,535	1,644	1,568	1,560	1,535
843	865	882	52	879	855	850	861	866	835	813	830
359	376	372	46	336	341	330	352	—	324	328	324
196[4]	216[5]	198[3]	06[6]	203[5]	186[5]	185[5]	195[5]	179[6]	196[6]	190[2]	199[6]
156[4]	143[5]	151[3]	40[6]	148[5]	139[5]	134[5]	146[5]	142[6]	139[6]	144[2]	140[6]
121	135	127	38	129	106	120	128	130	123	125	128
158·5	150	147	43	144	137	138	146	144	135	133	144
57	58	58	66	56	47	57	58	60	54	55	55
42	42	40	34	36	39	39	37	37	35	40	38
79·6[4]	66·2[5]	76·3[3]	·0[6]	72·9[5]	74·7[5]	72·4[5]	74·9[5]	79·8[6]	70·9[6]	75·8[2]	70·4[6]
76·6	90·0	86·4	·5	89·6	77·4	87·0	87·7	90·3	91·1	94·0	88·9
73·7	72·4	69·0	·5	64·3	83·0	68·4	63·8	61·7	64·8	72·7	69·1
44·2	44·6	44·7	·1	38·4	41·3	42·3	42·4	43·2	42·9	43·1	43·7
110·3	104·8	107·7	1·0	95·5	100·0	106·9	98·4	104·0	102·5	101·3	102·4
53·0	53·1	54·4	·6	58·6	55·5	55·2	55·2	54·8	54·6	52·8	55·4
22·6	23·1	23·0	·8	22·4	22·1	21·4	22·6	—	21·2	21·3	21·6

asured by Dr. G. M. We o. 44. [28] Father of No. 11. [29] Father of No. 12.
No. 38. [33] Mothe

I. Men

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Name	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tribe	Koskimo	[illegible]	Koskimo	[illegible]	Gyôp'ênôq	Koskimo	[illegible]	Koskimo	Koskimo	Koskimo	[illegible]	Koskimo	[illegible]	[illegible]	Nak'omgyilisala	[illegible]	Koskimo	[illegible]	Gyôp'ênôq	Koskimo	Koskimo	Koskimo	[illegible]	Koskimo	Nak'omgyilisala	Koskimo	Koskimo	Koskimo
Age	[illegible]	10	11	15	20	20	22	26	28	30	32	35	35	35	44	45	45	46	46	48	50	[illegible]	55	58	60	60	70	70
[illegible]	[illegible]	1,256	[illegible]	1,500	[illegible]	—	1,613	1,701	1,640	1,595	1,701	1,604	1,681	1,622	1,589	1,650	1,703	[illegible]	1,661	1,646	[illegible]	[illegible]	1,620	[illegible]	1,612	[illegible]	1,580	1,600
[illegible]	418	983	1,029	1,341	1,412	—	1,296	1,305	1,320	1,280	1,373	1,272	1,340	1,295	1,299	1,363	1,329	1,292	1,372	1,311	1,324	[illegible]	1,316	[illegible]	1,332	1,291	[illegible]	1,290
[illegible]	488	618	546	708	789	—	727	751	677	734	762	720	735	721	702	709	682	670	741	661	702	727	724	700	752	746	705	722
[illegible]	[illegible]	1,245	1,290	1,608	[illegible]	—	1,720	1,780	1,683	1,722	1,798	1,690	1,740	1,722	1,701	1,626	[illegible]	1,611	1,742	1,625	[illegible]	1,708	1,715	[illegible]	1,777	1,728	1,660	1,675
[illegible]	604	678	722	858	[illegible]	932	927	931	924	946	907	871	940	888	865	856	885	912	[illegible]	[illegible]	843	[illegible]	882	849	926	810	845	883
[illegible]	261	258	273	386	—	403	—	384	348	378	343	375	412	—	—	356	358	379	384	[illegible]	[illegible]	[illegible]	372	347	403	363	358	380
Length of head	183	173	171	191	186	189	192	190	208	192	199	197	202	193	183	182	189	[illegible]	206	197	[illegible]	216	[illegible]	198	208	201	208	200
[illegible]	160	148.5	[illegible]	156	153	162.5	159	150	158	151	155	152	159	162	150	161	149	156	150	146	166	143	151	144	159	154	160	153
[illegible]		100	101	122	113	128	126	130	130	130	125	129	130	131	128	126	127	131	125	119	121	135	127	123	132	121	136	143
[illegible]	[illegible]	124	126	146	144	151	152	148	144	144	153	141	148	153	147	153	147	152	147	149	158.5	150	147	144	161	153	159	154
[illegible]	8	43	43	52	54	58	52	53	51	59	48	52	60	53	57	57	56	58	55	55	57	58	55	57	61	53	60	69
[illegible]	1	30	35	39	38	40	42	39	40	38	39	37	40	38	38	39	36	38	[illegible]	40	42	42	40	39	41	42	38	41
Length-breadth index	87.4	85.8	86.0	81.7	82.3	86.1	82.8	79.0	76.0	78.6	77.9	77.2	78.7	84.0	82.0	83.9	78.8	78.4	72.8	74.1	73.6	66.2	76.3	72.7	76.4	76.6	76.9	76.5
Facial index	[illegible]	[illegible]	80.1	81.6	92.4	84.8	71.3	87.8	[illegible]	[illegible]	81.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81.6	82	[illegible]	86.1	92.9
Nasal index	81.6	69.8	81.4	75.0	70.4	68.9	80.9	73.6	78.4	64.4	81.3	71.2	66.7	64.4	66.7	68.4	64.3	65.5	70.9	83.6	73.7	72.4	61.0	68.4	67.2	79.3	63.3	59.4
Index of arm	[illegible]	[illegible]	42.4	[illegible]	45.1	-	45.2	44.2	[illegible]	46.1	41.2	[illegible]	[illegible]	44.5	[illegible]	[illegible]	42.9	41.1	[illegible]	40.1	43.2	[illegible]	44.7	[illegible]	44.5	47.8	44.6	45.1
Index of finger reach	[illegible]	[illegible]	[illegible]	101.2	[illegible]		106.8	104.7	102.6	[illegible]	105.8	105.6	[illegible]	106.1	107.1	98.5	[illegible]	101.0	[illegible]	[illegible]	[illegible]	104.8	107.7	[illegible]	105.2	110.7	105.0	104.7
Index of height, sitting	56.8	53.8	56.0	53.6	55.4	—	57.6	51.8	[illegible]	59.5	51.0	51.4	55.4	54.8	54.4	51.7	55.7	56.0	56.9	56.2	53.0	54.1	54.4	51.5	54.8	51.9	53.5	55.2
Index of width of shoulders	22.8	20.5	21.6	21.1	—	—	—	22.6	20.6	21.8	20.2	23.4	24.5	—	—	21.5	22.5	23.3	23.0	23.9	22.6	21.1	23.0	21.8	23.9	23.3	22.7	23.8

II. Females

Number	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
Name	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Tribe	Tlatlasikoala	Koskimo	[illegible]	Koskimo	Gyôp'ênôq	Koskimo	Gyôp'ênôq	Nak'omgyilisala	[illegible]	Gyôp'ênôq	Tlatlasikoala	Koskimo	Koskimo	Gyôp'ênôq	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo	Koskimo
Age	8	18	18	22	22	35	36	35	35	35	36	40	40	40	40	40	42	45	50	50	60
[illegible]	1,265	1,183	1,576	[illegible]	1,564	1,512	[illegible]	[illegible]	[illegible]	1,520	[illegible]	1,551	[illegible]	[illegible]	1,542	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,504
[illegible]	1,010	1,171	1,273	[illegible]	1,247	1,186	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,243	[illegible]	1,184	1,250	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,194
[illegible]	—	578	[illegible]	[illegible]	659	[illegible]	[illegible]	[illegible]	[illegible]	659	687	617	[illegible]	[illegible]	647	[illegible]	[illegible]	[illegible]	677	[illegible]	656
[illegible]	1,265	1,470	[illegible]	[illegible]	1,598	1,523	[illegible]	1,649	1,521	[illegible]	1,600	1,576	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1,614	[illegible]	[illegible]	1,535
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	846	[illegible]	[illegible]	[illegible]	852	846	853	820	[illegible]	879	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	813	850
[illegible]	—	334	335	363	356	346	371	—	339	322	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	352		[illegible]	[illegible]	324
Length of head	186	188	187	186	188	199	194	197	174	188	191	192	[illegible]	[illegible]	[illegible]	[illegible]	195	179	[illegible]	[illegible]	199
[illegible]	163	160	152	150	150	145	148	151	144	146	146	141	[illegible]	[illegible]	[illegible]	[illegible]	140	142	[illegible]	144	140
[illegible]	112	113	118	124	130	119	129	116	121	130	117	114	138	129	106	[illegible]	[illegible]	130	[illegible]	125	128
[illegible]	134	146	146	143	145	142	147	141	140	140	135	138	143	144	[illegible]	[illegible]	146	144	[illegible]	[illegible]	144
[illegible]	51	50	50	48	54	54	53	53	53	52	50	49	[illegible]	56	47	57	58	[illegible]	51	[illegible]	55
[illegible]	36	31	33	35	38	33	39	35	35	32	37	35	34	[illegible]	[illegible]	39	37	37	35	40	38
Length-breadth index	82.3	85.1	81.3	79.8	79.8	72.9	76.3	76.6	82.6	77.7	76.4	73.4	[illegible]	[illegible]	74.7	72.4	[illegible]	79.6	70.9	75.8	70.4
Facial index	83.6	77.1	80.8	86.7	89.6	83.8	87.8	[illegible]	86.4	92.9	86.7	82.5	96.5	89.6	77.4	87.0	87.7	90.3	91.1	94.0	88.9
Nasal index	70.6	62.0	66.0	72.9	70.4	61.1	73.6	66.0	66.0	61.5	74.0	71.4	51.5	[illegible]	[illegible]	69.4	63.8	61.7	64.8	72.7	69.1
Index of arm		38.8	41.6	41.7	42.3	41.5	42.0	43.1	41.4	43.4	43.9	41.7	42.1	38.4	41.3	[illegible]	42.4	43.2	42.9	43.1	43.7
Index of finger reach	[illegible]	98.7	102.2	102.2	102.5	[illegible]	102.8	[illegible]	[illegible]	104.1	102.5	101.7	101.0	95.5	100.0	106.9	98.4	104.0	102.5	101.9	102.4
Index of height, sitting	55.1	55.7	54.6	58.1	54.2	56.4	51.7	54.1	55.0	55.7	54.7	52.9	53.6	58.6	55.5	55.2	55.2	54.8	54.6	52.8	55.4
Index of width of shoulders	—	22.4	21.2	24.4	22.8	22.9	22.8	—	21.9	21.2	—	21.5	21.8	22.4	22.1	21.4	22.6	—	21.2	21.3	21.6

[1] Not deformed. [2] Slightly deformed. [3] Moderately deformed. [4] Considerably deformed. [5] Much deformed. [6] Very much deformed. [?] Measured by Dr. G. M. West. [?] One leg deformed. [?] Son of No. 24. [?] Son of No. 26. [?] Father of No. 30. [?] Brother of No. 44. [?] Father of No. 11. [?] Father of No. 12. [?] Daughter of Nos. 17 and 34. [?] Daughter of No. 49. [?] Sister of No. 38. [?] Mother of No. 30. [?] Sister of No. 33. [?] Sister of No. 21. [?] Mother of No. 32.

7A. Kwakiutl Half-bloods. *8. Sishiatl.*

I. Males		II. Female	I. Boy	II. Girls	
1	2	3	1	2	3
Maqmusā'k·amē	Gō'lsalis	Mō'p'ēnestaak'	Thomas	Lucy Louis	Magdalen Andrew
F. American M. Walaskwakiutl	F. Iroquois M. Kwakiutl	F. White M. Koskimo	Sishiatl	Sishiatl	Sishiatl
20	26	23	11	5	11
mm. 1716	mm. 1,662	mm. 1,510	mm. 1,307	mm. 1,066	mm. 1,350
1,410	1,390	1,201	1,035	820	1,102
790	760	627	573	432	580
1,968	1,824	1,560	1,338	1,050	1,340
895	874	858	704	576	728
400	404	358	282	239	307
183[1]	184[1]	187[1]	180	159	171
154[1]	151[1]	154[1]	147	145	156
125	124	125	104	90	100
147	145	147	127	121	135
53	50	52	41	35	38
40	39	33	30	29	35
84·2[1]	82·1[1]	82·4[1]	81·6	91·2	91·5
85·0	85·5	85·0	81·9	74·4	74·1
75·5	78·0	63·5	73·2	82·9	92·1
45·9	45·8	41·5	43·7	40·4	43·0
114·4	109 9	103·3	102·1	98·2	99·3
52·0	52·7	56·8	53·7	53·8	53·9
23.3	24·3	23·7	21·5	22·3	22·7

[43] Sister of No. 20. [44] Sister of No. 18

6. *Nootka* — 7. *Kwakiutl, Ma'malelek ala, Nē'mk ic*

	6. Nootka: Women		7. I. Males														
No.	1	2	[illegible]	[illegible]	3	[illegible]	[illegible]	6	7	8	9	[illegible]	11	12	13	14	15
Name	[illegible]	[illegible]	Wā'wātlkyīne	[illegible]	Wa'nuk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Ta'nkult	Koē'qnagyilak'	Malē'tē	Kyā'tō	[illegible]	[illegible]	[illegible]
Tribe	Tsé'k tls'atq	Tsé'k tls'atq	F K'ómoyue M Dīnu'tsla	F Kwakiutl M Walaskwakiutl	F Kwakiutl M Lā'kwiltōk	F Kuē'qa M Walaskwakiutl	F Koē'k[illegible] M Nē'mk ic	F Tsē'watEēnōq M Kwakiutl	F Guē'tsla M Ma'malelek ala	F Walaskwakiutl M Ma'malelek ala	F Walaskwakiutl M Nē'mk ic	F ½ Kwakiutl, ½ Hē'iltsuk M Hē'iltsuk	Kwakiutl	Walaskwakiutl	F Walaskwakiutl M Kuē'qa	F Walaskwakiutl M K'ó'moyue	K'ó'moyue
Age	23	40	13	15	25	26	30	35	35	36	38	38	42	42	50	60	65
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	1,641	[illegible]	[illegible]	[illegible]	1,652	[illegible]	1,662	1,740	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		1,610	[illegible]	[illegible]
Height of shoulder	1,317	1,314	1,060	1,236	1,310	1,383	1,394	1,430	1,284	1,303	1,328	1,362	1,281		1,333	1,275	1,323
Length of arm	659	705	573	642	741	759	—	787	702	711	715	760	694	—	713	692	714
Finger reach	1,682	1,650	1,350	1,515	1,757	1,788	1,826	1,848	1,668	[illegible]	1,765	1,782	1,659	1,716	1,722	1,638	1,750
Height, sitting	840	856	691	800	911	968	839	952	880	891	892	885	846	916	876	850	858
Width of shoulders	383	356	275	321		392	—	375	337	377	364	392	—	364	392	351	
Length of head	188[1]	192[4]	182[1]	179[1]	192[1]	189[2]	205[1]	200[4]	187[3]	184[4]	190[4]	184[1]	181[2]	191[2]	191[3]	—	186[1]
Breadth of head	161[1]	146[1]	150[1]	158[4]	160[3]	163[2]	158[4]	170[2]	168[3]	159[2]	156[4]	160[1]	161[5]	156[4]	163[2]	158	157[4]
Height of face	118	120	107	[illegible]	133	131	141	[illegible]	[illegible]	[illegible]	[illegible]	117	131	[illegible]	121	[illegible]	[illegible]
Breadth of face	146.5	145	126	140	147	147	148	151	152	148	141	144	156	151	150	163	147
Height of nose	47	52	42	45	57	56	58	61	60	56	48	52	58	56	52	57	62
Breadth of nose	34	35	32	35	35	38	43	43	38	37	37	35	41	[illegible]	36	41	42
Length-breadth index	[illegible]	76.0[4]	82.4[1]	88.3	83.3[3]	86.2[2]	77.1[1]	85.0[4]	89.8[2]	86.4[2]	82.1	87.0[1]	[illegible]	[illegible]	85.3[3]	—	84.4[4]
Facial index	80.8	82.8	84.9	81.4	90.5	89.1	[illegible]	91.0	[illegible]	85.2	89.1	81.2	[illegible]	[illegible]	82.7	55.0	93.9
Nasal index	72.3	67.3	76.2	77.8	61.4	69.1	74.2	84.3	63.3	66.1	77.1	67.3	69.0	76.8	69.2	71.9	69.3
Index of arm	41.2	44.3	44.8	42.2	45.5	41.9	—	45.0	44.1	46.0	44.8	44.9	44.2	—	44.7	44.6	46.5
Index of finger reach	105.1	[illegible]	105.5	99.7	107.8	105.8	110.0	105.6	103.6	106.6	109.1	106.7	108.2		105.0	105.7	109.4
Index of height, sitting	52.5	56.4	54.2	52.6	[illegible]	[illegible]	51.2	54.4	55.7	56.0	54.4	53.1	[illegible]	—	53.4	54.8	62.4
Index of width of shoulders	23.9	22.3	21.5	21.1	—	[illegible]		21.1	21.3	23.7	22.2	23.5			23.9	22.8	—

	7. II. Females															
No.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
Name	[illegible]	[illegible]	[illegible]		Wā'[illegible]dalak	Kyē'[illegible]nustok'	Tlā'tla[illegible]	Tō'k[illegible]	Ō'm[illegible]	Hay[illegible]	K[illegible]tlala	Hā'[illegible]	Yī'mk[illegible]	Tlāsem[illegible]	Tlā'qtl[illegible]	Hā'[illegible]
Tribe	Ma'malelek ala	Ma'malelek ala	F Nē'mk ic M Kwakiutl	Ma'malelek ala	F Nē'mk ic M Kwakiutl	Nē'mk ic	F Nē'mk ic M Dīnu'tsla	F Walaskwakiutl M Nē'mk ic	Nē'mk ic	F ½ Kuē'qa, ½ Tsā'[illegible] M. Tsā'[illegible]	F Ma'malelek ala M Kwakiutl	Nē'mk ic	F Ma'malelek ala M Kuē'qa	Walaskwakiutl	Walaskwakiutl	Kuē'qa
Age	1	6	8	11	13	18	18	22	28	30	36	38	40	46	60	70
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	[illegible]	[illegible]	[illegible]	1,353	1,466	[illegible]	1,513	1,562	1,433	[illegible]	1,562	1,634	[illegible]	1,464	1,483	1,477
Height of shoulder	768	867	995	1,100	1,163	1,234	1,358	1,292	1,234	1,220	1,250	1,353	1,223	1,195	1,236	1,219
Length of arm	406	449	524	—	658	686	—	694	667	640	657	683	649	655	656	714
Finger reach	975	1,057	1,292	1,398	1,513	1,563	1,591	1,674	1,580	1,592	1,585	1,658	1,540	1,563	1,608	1,604
Height, sitting	673	565	686	726	751	823	831	837	838	831	852	923	785	801	862	764
Width of shoulders	218	226	257	309	315	325	—	—	335	362	351	312	327	346	348	308
Length of head	146[1]	171[1]	172[1]	177[4]	181[1]	177[1]	187[3]	190[4]	180[4]	187[4]	168[1]	188[6]	181[2]	179[6]	182[6]	185[3]
Breadth of head	139[1]	140[1]	143[1]	147[2]	150[1]	154[1]	159[3]	162[2]	155[3]	154[2]	153[1]	165[6]	148[2]	152[3]	153[3]	145[3]
Height of face	87	91	101	114	104	111	127	128	111	116	115	123	120	119	119	117
Breadth of face	117	112	123	135	132	140	148	139	135	146	144	151	139	145	149	147
Height of nose	33	38	40	43	40	49	60	67	44	47	45	46	45	52	49	53
Breadth of nose	25	29	30	33	33	32	33	35	31	35	35	36	30	36	42	[illegible]
Length-breadth index	83.7[1]	81.9[1]	83.1[1]	83.1[2]	81.5[1]	87.0[1]	[illegible]	90.0[2]	86.1[2]	82.3[2]	82.7[1]	87.8[6]	81.8[2]	84.9[3]	84.1[3]	78.4[3]
Facial index	74.1	81.9	82.1	84.5	78.1	79.3	85.8	92.1	84.5	79.5	79.9	81.5	86.1	82.1	79.9	80.4
Nasal index	81.8	76.3	75.0	76.7	82.5	74.4	55.0	61.4	70.5	74.5	77.8	82.6	66.7	69.2	85.7	69.8
Index of arm	41.0	41.6	41.6	—	45.1	46.0	—	44.5	44.8	42.4	42.4	41.9	43.3	44.9	47.0	48.3
Index of finger reach	98.5	97.6	100.0	103.6	103.7	104.9	104.9	107.4	106.1	105.5	102.3	101.7	102.7	107.1	108.7	108.4
Index of height, sitting	57.6	52.3	54.5	53.8	51.4	53.2	54.7	53.7	56.2	55.3	55.0	56.6	52.3	55.0	58.2	51.6
Index of width of shoulders	22.0	20.9	20.4	22.9	21.6	21.8	—	—	22.6	24.0	22.6	21.1	21.5	23.6	23.5	20.8

	7a. Kwakiutl Half-bloods: I. Males		II. Female	8. Sishiatl: I. Boy	II. Girls	
No.	1	2	[illegible]	1	[illegible]	[illegible]
Name	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Andrew
Tribe	F American M Walaskwakiutl	F Iroquois M Kwakiutl	F White M Koskimo	Sishiatl	Sishiatl	Sishiatl
Age	20	[illegible]	21	11	5	11
	mm	mm	mm	mm	mm	mm
Height standing	[illegible]	[illegible]	[illegible]	1,307	1,166	[illegible]
Height of shoulder	1,110	1,300	1,201	1,036	820	[illegible]
Length of arm	730	760	627	573	432	580
Finger reach	1,568	1,824	1,560	1,338	1,050	1,340
Height, sitting	895	874	858	704	676	[illegible]
Width of shoulders	400	404	358	282	239	307
Length of head	183[4]	184[1]	187[4]	160	169	171
Breadth of head	151[4]	151[1]	154[4]	147	145	156
Height of face	125	121	125	104	90	100
Breadth of face	147	145	147	127	121	135
Height of nose	53	60	52	41	35	38
Breadth of nose	40	39	33	30	29	35
Length-breadth index	84.2	82.1[1]	82.4[1]	81.6	[illegible]	91.5
Facial index	[illegible]	85.5	85.0	81.9	74.1	74.1
Nasal index	75.5	78.0	63.5	73.2	82.9	92.1
Index of arm	45.9	45.8	41.5	43.7	40.4	44.0
Index of finger reach	114.4	109.9	103.3	102.1	98.2	99.3
Index of height, sitting	52.0	52.7	56.8	53.7	53.8	53.9
Index of width of shoulders	23.3	21.3	23.7	21.5	22.3	22.7

[1] Not deformed. [2] Slightly deformed. [3] Moderately deformed. [4] Considerably deformed. [5] Much deformed. [6] Very much deformed. [10] Measured by Dr. G. M. West. [11] Daughter of No. 2. [12] Mother of No. 1. [13] Son of No. 15. [14] Father of No. 1. [15] Sister of No. 17. [16] Sister of No. 16. [17] Sister of No. 20. [18] Sister of No. 18.

10. *Tribes of Harrison River.*

10A. *Half-blood Stsɛē'lis.*

	Girls	I. Boys				II. Girls				Boy
Number	22	4	5	6	7	8	9	10	11	12
Name	Christine Joseph	Alexander	Jackson	William	William Philip	Minnie	Mary James	Emily James	Cécile Lewis	Thomas Purcell
Tribe	F. Ntlakyapamuq M. Pɛlā'tlq	Sk·au'elitsk	Stsɛē'lis	Sk·au'elitsk	Stsɛē'lis	Stsɛē'lis	Sk·au'elitsk	Sk·au'elitsk	Sk·au'elitsk	F. ½ Stsɛē'lis, ½ White M. ½ Stsɛē'lis
Age	12	12	13	13	14	8	11	14	16	9
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm	mm.
Height, s	1,450	1,273	1,427	1,450	1,512	1,200	1,366	1,197	1,468	1,198
Height o	1,162	1,030	1,156	1,170	1,211	958	1,094	1,213	1,198	984
Length o	641	547	590	651	658	517	609	654	646	534
Finger-re	1,518	1,290	1,433	1,513	1,580	1,197	1,424	1,523	1,520	1,217
Height, s	770	677	778	768	787	653	726	796	785	646
Width of	332	291	287	325	357	253	304	318	328	263
Length o	182	175	177	190	181	166	167	182	162	171
Breadth	154	148	156	158	157	143	146	165	153	153
Height o	101	102	100	112	111	94	105	111	102	95
Breadth	135	126	132	136	141	122	126	141	137	124
Height o	41	39	38	49	44	39	46	48	39	38
Breadth	35	34	35	33	39	30	34	35	34	33
Length-b	84·6	84·6	88·1	83·2	86·7	86·1	87·4	90·7	94·4	89·5
Facial in	74·8	81·0	75·8	82·4	78·7	77·0	83·3	78·7	74·5	76·6
Nasal ind	85·4	87·2	92·1	67·3	88·6	76·9	73·9	72·9	87·2	86·6
Index of	44·2	43·1	41·3	44·9	43·6	43·1	44·5	43·6	43·9	44·5
Index of	104·7	101·7	100·2	104·3	104·6	99·8	103·9	101·5	103·4	101·4
Index of	53·1	53·3	54·4	53·0	52·1	54·4	52·6	53·1	53·4	53·9
Index of	22·9	22·9	20·1	22·4	23·6	21·1	22·2	21·2	22·3	23·6

9. Tribes of the Delta of Fraser River.

	I. Boys											II. Girls		
No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name	Larry	[illegible]	Dave	Jimmy	Willy	Patrick Tommy	Casimir	Davis Stewart	Jimmy Amory	Patrick Johnny	Simon	Annie Cream	Marianne Paul	Maggie Andrew
Tribe	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Tc'ilEqoe'uk	[illegible]	Ewa'wus	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	F. Ewa'wus, M. [illegible]
Age	7	9	9	9	10	10	11	11	13	13	14	7	8	9
Height	mm. 1,17?	mm. 1,180	mm. 1,2??	mm. 1,?01	mm. [illegible]	mm. 1,2??	mm. [illegible]	mm. 1,422	mm. 1,418	mm. 1,42?	mm. 1,418	mm. 1,1?5	mm. 1,?41	mm. [illegible]
[illegible] shoulder	88?	942	950	944	1,051	976	1,123	1,075	1,173	1,154	1,152	881	950	1,005
[illegible]	48?	505	508	510	561	561	618	610	631	622	631	469	548	561
[illegible]	1,?73	1,180	1,2?5	1,227	1,323	1,296	1,427	1,426	1,470	1,470	1,468	1,160	1,252	1,292
[illegible]	635	646	674	?72	707	?83	724	696	717	756	771	587	680	653
[illegible] of shoulders	252	276	282	274	269	285	318	283	309	308	324	245	289	252
[illegible]	17?	177	16?	172	16?	174	181	167	177	176	167	175	170	176
[illegible]	15?	1?3	152	1?7	15?	160	154	15?	155	148	150	148	151	148
[illegible] of face	94	95	100	99	102	105	96	96	112	105	101	92	102	101
[illegible]	127	12?	1?1	13?	[illegible]	[illegible]	136	13?	131	127	134	120	131	129
[illegible]	35	37	38	3?	40	41	36	37	40	42	42	36	42	37
[illegible] width of nose	33	33	34	32	36	32	34	33	35	33	33	28	31	34
[illegible] index	92.2	80.8	90.0	91.?	92.3	92.0	84.5	93.1	87.6	84.1	[illegible]	84.6	90.5	84.1
[illegible] index	74.0	77.2	76.?	73.9	76.7	76.1	70.6	71.1	85.5	82.7	75.1	76.7	77.9	78.3
[illegible] index	94.3	89.2	89.5	82.0	90.0	78.0	94.4	89.2	87.5	78.6	78.6	77.8	73.8	91.9
[illegible]	41.6	42.8	41.0	42.5	42.4	45.2	45.1	46.2	44.1	47.5	44.4	41.2	44.2	44.9
[illegible] of finger-reach	100.0	100.1	100.0	102.2	101.8	104.5	104.2	108.0	103.5	102.8	103.4	102.7	101.0	103.4
[illegible] height, sitting	54.7	54.7	54.4	55.2	54.1	52.7	52.8	52.7	52.6	52.9	54.3	52.4	54.8	53.2
[illegible] of width of shoulders	21.7	23.4	22.7	22.9	22.2	23.0	23.2	21.4	21.8	21.5	22.8	21.9	23.3	22.6

	II. Girls (continued)													
No.	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Name	Cécile Joseph	Susanne George	Mathilda William	Louise Joseph	Christine Andrew	Celestine Victor	Christine Tom	Christina Joseph	Emily Joseph	Emma Dick	Josephine Michel	Alice William	Isabella Billy	Lizzie Charles
Tribe	Tc'ilEqoe'uk	Tc'ilEqoe'uk	F. [illegible], M. [illegible]	Tc'ilEqoe'uk	F. Seattle, M. Tulalip	[illegible]	Ruby Creek	F. [illegible], M. Pila'tlq	Tc'ilEqoe'uk	F. [illegible], M. Tc'ilEqoe'uk	F. [illegible], M. K'e'e'tsi	F. Lak'a'mEl, M. Ntlakya'pamuq	F. Lillooet, M. K'e'e'tsi	F. K'ek'amtel, M. Ewa'wus
Age	10	11	11	11	12	12	12	12	12	15	14	15	15	16
Height	mm. [illegible]	mm. 1,37?	mm. 1,447	mm. 1,4??	mm. [illegible]	mm. 1,1?2	mm. [illegible]	mm. [illegible]	mm. 1,?01	mm. [illegible]	mm. 1,?05	mm. 1,?82	mm. 1,1?4	mm. [illegible]
[illegible] shoulder	1,122	1,107	1,152	1,148	1,147	1,131	1,103	1,162	1,227	1,193	1,136	1,176	1,197	1,220
[illegible]	630	687	628	598	617	584	596	641	675	646	628	621	658	644
[illegible]	1,446	1,?78	1,473	1,390	1,487	1,404	1,385	1,618	1,640	1,542	1,449	1,488	1,667	1,640
[illegible]	71?	740	77?	778	76?	766	732	77?	816	781	710	[illegible]	81?	[illegible]
[illegible] of shoulders	312	288	312	292	310	324	300	312	323	333	320	344	347	335
[illegible]	17?	17?	18?	174	17?	171	178	[illegible]	173	171	168	180	180	178
[illegible]	148	176	151	157	144	149	152	15?	151	17?	145	151	151	1?8
[illegible] of face	105	105	111	114	109	103	110	101	112	104	101	113	103	112
[illegible]	129	135	13?	[illegible]	126	137	132	1?5	1?0	137	131	131	1?7	136
[illegible]	41	41	41	48	4?	42	47	41	48	42	41	41	46	49
[illegible] width of nose	30	32	34	33	31	33	34	36	36	32	31	36	35	33
[illegible] index	87.1	88.6	82.5	90.2	80.4	87.1	85.4	84.?	8?.?	88.9	86.?	83.9	8?.9	89.1
[illegible] index	81.4	77.8	83.5	86.1	86.5	75.2	83.4	74.8	86.2	75.9	77.1	81.3	75.2	82.4
[illegible] index	73.2	72.7	82.9	68.8	76.7	83.3	72.4	85.4	75.0	76.2	82.0	81.7	76.1	67.3
[illegible]	45.3	42.8	43.3	42.7	41.8	41.7	43.8	44.2	47.0	43.3	44.5	42.1	41.8	42.0
[illegible] of finger-reach	104.0	99.8	101.6	99.3	105.5	100.0	101.8	101.7	102.7	104.9	102.8	100.1	106.5	102.7
[illegible] height, sitting	52.8	54.0	53.5	55.6	54.2	54.7	53.8	53.4	5?.4	5?.1	52.5	54.1	54.6	53.3
[illegible] of width of shoulders	22.4	21.0	21.5	20.9	22.0	23.1	22.1	22.9	21.6	22.8	22.7	23.2	23.3	22.3

9a. Half-bloods, Delta of Fraser River.

	II. Girls (9, cont.)			I. Boy (9a)		II. Girls (9a)							
No.	29	30	31	32	33	34	35	36	37	38	39	40	41
Name	Sarah	Mary Pierre	Magdalene Charlie	Edmond	Emilian Andrews	Ida	Cécile Andrews	Annie	Josephine Pierre	Maggie Joseph	Marianne Bailey	Lizzie Louis Edward	Magdalene Andrews
Tribe	F. Tc'ilEqoe'uk, M. Tulalip	F. Ewa'wus, M. Tulalip	F. Ruby Creek, M. [illegible]	F. Matsqui, ½ White, M. [illegible]	F. Spanish, M. Sk'a'mic	F. Tc'ilEqoe'uk, M. Kanaka	F. Spanish, M. Sk'a'mic	F. Tc'ilEqoe'uk, M. Kanaka	F. Tc'ilEqoe'uk, M. Kanaka	F. Indian, M. ½ [illegible], ½ Kanaka	F. ½ White, ½ [illegible], M. Sk'a'mic	F. ½ Matsqui, ½ White, M. Pila'tlq	F. Spanish, M. Sk'a'mic
Age	17	17	18	9	6	8	9	9	10	11	11	12	12
Height	mm. [illegible]	mm. [illegible]	mm. [illegible]	mm. 1,28?	mm. 1,06?	mm. 1,193	mm. 1,?55	mm. 1,?50	mm. 1,4?0	mm. [illegible]	mm. 1,?08	mm. 1,4??	mm. 1,111
[illegible] shoulder	1,190	1,227	1,215	1,013	845	925	1,040	974	1,122	1,103	1,120	1,181	1,140
[illegible]	618	641	643	560	435	473	540	539	609	587	559	627	623
[illegible]	1,650	1,572	1,510	1,304	1,053	1,216	1,293	1,308	1,430	1,430	1,360	1,516	1,421
[illegible]	81?	8?2	824	6??	?8?	?61	[illegible]	68?	77?	712	781	7??	727
[illegible] of shoulders	304	350	318	285	237	282	279	286	307	301	311	340	287
[illegible]	181	181	171	170	17?	172	170	176	175	173	182	177	171
[illegible]	176	156	147	149	140	150	150	176	157	147	143	150	13?
[illegible] of face	115	110	105	96	97	94	102	109	110	103	109	102	98
[illegible]	141	144	1??	1??	1??	129	12?	134	137	128	126	132	124
[illegible]	48	42	41	40	?7	37	43	43	47	46	43	45	41
[illegible] width of nose	36	34	36	32	28	32	31	32	34	29	32	32	26
[illegible] index	86.2	86.2	86.0	87.7	80.?	87.2	88.2	88.6	8?.7	85.0	78.?	84.7	81.?
[illegible] index	81.6	76.4	78.3	72.2	82.2	72.9	73.1	76.1	81.5	8?.?	86.5	77.2	79.7
[illegible] index	72.9	80.9	87.8	80.0	75.7	86.5	72.1	84.4	72.4	63.0	84.4	91.1	69.4
[illegible]	44.1	41.6	42.3	44.5	41.1	39.7	41.9	43.1	41.2	4?.2	40.0	43.2	44.2
[illegible] of finger-reach	105.4	100.8	101.3	101.9	99.1	102.1	100.0	104.6	101.4	105.2	97.1	104.6	100.8
[illegible] height, sitting	55.3	56.0	54.2	54.1	5?.4	55.8	53.7	54.6	55.1	52.4	55.8	52.8	51.6
[illegible] of width of shoulders	24.8	22.7	20.9	22.?	22.4	23.7	21.6	22.9	21.8	22.1	22.2	23.5	20.4

10. Tribes of Harrison River. — 10a. Half-blood Stalo.

	I. Boys (10)								II. Girls (10)			Boy (10a)
No.	1	2	3	4	5	6	7	8	9	10	11	12
Name	Alexander	Andrew	Harry Skaatats	Alexander	Jackson	William	William Philip	Minnie	Mary Jane	Emily James	Cécile Lewis	Thomas Purcell
Tribe	Stse'ēlis	Stse'ēlis	Sk'au'elitsk	Sk'au'elitsk	Stse'ēlis	Sk'au'elitsk	Stse'ēlis	Stse'ēlis	Sk'au'elitsk	Sk'au'elitsk	Sk'au'elitsk	F. ½ Stse'ēlis, ½ White, M. ½ Stse'ēlis
Age	9	10	11	12	13	13	14	8	11	14	16	9
Height	mm. 1,2?3	mm. 1,?02	mm. 1,259	mm. 1,27?	mm. 1,1?7	mm. 1,4??	mm. 1,?12	mm. ?,208	mm. [illegible]	mm. 1,?97	mm. 1,168	mm. 1,198
[illegible] shoulder	1,004	1,022	985	[illegible]	1,166	1,170	1,211	958	1,091	1,219	1,198	981
[illegible]	538	572	560	547	[illegible]	651	658	517	609	654	646	534
[illegible]	1,2?3	1,350	1,302	1,290	1,433	1,513	1,580	1,197	1,421	1,523	1,520	1,217
[illegible]	[illegible]	6?	677	677	77?	[illegible]	?87	?5?	72?	7??	?85	?16
[illegible] of shoulders	275	282	288	291	257	325	357	263	304	318	328	263
[illegible]	168	169	183	175	177	196	181	166	167	182	162	171
[illegible]	156	150	152	148	156	158	157	143	146	1?5	15?	153
[illegible] of face	101	97	109	102	103	112	111	94	105	111	102	95
[illegible]	126	130	132	126	132	136	141	122	126	141	137	124
[illegible]	43	40	43	[illegible]	38	4?	41	39	46	48	39	48
[illegible] width of nose	30	32	36	34	35	33	39	30	31	35	34	33
[illegible] index	92.9	88.8	83.1	81.?	83.1	83.2	86.7	86.1	87.4	90.7	94.4	89.5
[illegible] index	80.2	74.6	78.1	81.0	75.5	82.4	78.7	77.0	83.3	78.7	74.5	76.6
[illegible] index	69.8	80.0	83.7	87.2	92.1	67.3	88.6	76.9	73.9	72.9	87.2	86.6
[illegible]	42.7	44.0	44.4	43.1	41.3	44.9	43.6	44.1	44.5	43.6	43.9	44.5
[illegible] of finger-reach	102.6	103.8	103.3	101.7	100.2	104.3	104.6	99.8	103.9	101.5	103.4	101.4
[illegible] height, sitting	55.1	53.5	53.7	53.3	51.4	53.0	52.1	54.4	52.6	53.1	51.4	53.9
[illegible] of width of shoulders	21.8	21.7	22.9	22.9	20.1	22.4	23.6	21.1	22.2	21.2	22.5	23.6

[1] Brother of No. 28. [2] Sister of No. 23. [3] Sister of No. 15. [4] Sister of No. 9.

um	23	24	25	26	27	43	44	45	46	47	48	49	50
am	Billy Dick Sîltsî'QEn	?	Nicolas	Swasida'lst	Alexis	Cî'qala	Ha'tlsdEm	Cîlpî'tza	Pak·ôyatEn	Tqoaliqk·ē'n	Lā'ict	Nqā'tEmEk·an	Kulā'ta
rib	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar	Utamk·t of North Bend and Boston Bar
ge	6	9	9	9	9	55	58	60	60	65	65	70–75	75
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
eig[8]	1,224	1,258[9]	1,280	1,370	1,303	1,492	1,555	1,622	1,566	1,538	1,620	1,572	—
eig	971	1,023	1,138	1,116	1,053	1,218	1,258	1,350	1,292	1,280	1,308	1,313	—
eng	516	523	636?	573	551	663	682	713	760	672	741	716	—
ing	1,198	1,220	1,285	1,392	1,292	1,510	1,610	1,745	1,707	1,552	—	1,672	1,558
eig	644	693	698	723	707	790	830	816	808	797	843	815	793
idt	246	251	274	308	290	327	365	364	334	354	348	361	348
eng	168	171·5	176	177	180	177	195	188	191	182	185	176	188
rea	151	147	151	148·5	150	151	155	162	160	151	154	156	160
eig	101	101	96	106	103	110	130	118	124	121	130	130	117
rea	128	127	128	130	130	139	149	153	150	148	143	146	153
eig	42	40	40	42	43	53	55	47	55	51	56	62	57
rea	35	31	35	35	35	41	40	41	43	38	40	38	43
eng	89·9	86·0	85·8	83·9	83·3	85·3	79·5	86·2	83·8	83·0	83·2	88·6	85·1
aci	78·9	79·5	75·0	81·5	79·3	79·1	87·3	77·1	82·7	81·8	90·9	79·0	76·5
asa	83·3	77·5	87·5	83·3	81·4	77·4	72·7	87·2	78·2	74·5	71·4	61·3	75·4
nde	42·3	41·5	49·7?	41·8	42·4	44·5	44·0	44·0	48·4	43·7	45·7	45·6	—
nde	98·2	96·8	100·4	101·6	99·4	103·0	103·9	107·7	108·7	100·8	—	106·5	—
le	52·8	55·0	54·5	52·8	54·4	53·0	53·5	50·4	51·5	51·8	52·0	51·9	—
le	21·6	19·9	21·4	22·5	22·3	22·0	23·5	22·5	21·3	23·0	21·5	23·0	—

8. [5] Son of No. 10; brother … rother of No. 28. [10] Brother of No. 24.
[12] Father of No. 20. [13] F

a. Utamqt of Spuzzum — I. Males (Nos. 1–9); II. Females (Nos. 10–15)

b. Utamqt of Spuzzum and Upper Divisions mixed — Males (Nos. 16–19)

c. Upper Utamqt of Boston Bar and North Bend — I. Males (Nos. 20–50)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Name	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Capt. [illegible]	Jo[illegible]	Silas Spuzzumkt	Hakate'intra	Ylepa'tgō	Anne	Yi'atgō	La'lsa	Saai'tak	Cxam't'u	Skula'tl'akt	Skaspa'kt	[illegible]	Amos	Harry	David	Billy Dan[illegible]	[illegible]	Nicolas
Locality	Utamqt of Spuzzum	[illegible]	[illegible]	[illegible]	[illegible]	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	Utamqt of Spuzzum	[illegible]	[illegible]	[illegible]	[illegible]	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	[illegible]	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
[illegible]	[illegible]	1,575	[illegible]	1,580	[illegible]	1,310	1,245	1,360	1,274	1,213	1,256	1,284	1,270		1,187	1,310	1,205	1,310	—	[illegible]		[illegible]	[illegible]	1,023	1,138
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	685	760	702	678	701	[illegible]	678		[illegible]	691	[illegible]	713	-	457		441	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	1,725	[illegible]	1,707	1,620	1,775	1,657	1,590	1,645	[illegible]	1,538	[illegible]	[illegible]	1,667	[illegible]	1,690	1,700	723		[illegible]	[illegible]	1,220	1,286
[illegible]				[illegible]		[illegible]	[illegible]	[illegible]	829	788	760	834	777	781	746	858	831	824	858	483	512	593	611	[illegible]	635
[illegible]	350	400	[illegible]	375	[illegible]	352	418	378	358	471	352	56			352	361	[illegible]	[illegible]	310		210	225	[illegible]	[illegible]	274
[illegible]	[illegible]	198	185		183	191	181	181	172	181	183	189	181	182	180	185	186	181	203	166	179	173	168	171·5	176
[illegible]	148	158	172		156	168	168	159	155	157	151	151	153	152	147	155	164	171	151	148	147	151	151	147	151
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]	116	[illegible]	114	111	119	[illegible]	112	[illegible]	111	121	117	82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	117	145	[illegible]	151	155	157	147	148	143	118	146	141	112	141	118	141	146	115	120	125	[illegible]	127	128
[illegible]	[illegible]	[illegible]	[illegible]	50	44	56	50	57	52	55	50	45	50	[illegible]	52	43	45	51	50	[illegible]	32	57	42	40	40
[illegible]	[illegible]	[illegible]		40	[illegible]	43	40	41	38	40	40	36	42	35	38	42	38	[illegible]	40	27	[illegible]	[illegible]	[illegible]	[illegible]	35
[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81·5	[illegible]	79·1	[illegible]	[illegible]	[illegible]	75·9	81·2	[illegible]	[illegible]	[illegible]	80·0	[illegible]
[illegible]	79·7	85·7	78·2	82·1	72·1	65·1	77·4	84·1	72·0	79·7	79·0	77·0	81·5	72·2	78·1	81·4	77·0	85·8	80·1	71·9	70·8	76·8	73·9	79·5	75·0
[illegible]	82·2	63·6	75·0	80·0	88·6	76·8	80·0	77·2	73·1	72·7	86·0	80·0	84·0	81·4	73·1	97·7	84·4	70·6	80·0	84·4	90·6	78·4	80·3	77·5	87·6
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	44·7	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	101·9	91·2	100·1	[illegible]	105·7	105·6	[illegible]	[illegible]		[illegible]	98·2	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52·6	51·6	52·8	51·8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	52·6	[illegible]	[illegible]	51·7	[illegible]	57·4	[illegible]	52·8	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21·7	22·8	[illegible]	[illegible]	22·7			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	22·1	[illegible]	[illegible]	[illegible]

	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Name	[illegible]	Alexis	Joseph	Andrew Bob	George Magnuts	Lataja	Jimmy Camp	Harry Skazi	Jack Thompson Phl'ulk[illegible]	Sam Cook's Ferry	Delojak C'n	Ya'ek'win	Charlie Tsikwatsin	Sel[illegible]	Qoe'lika	Nkolk'tch'at	Qana'uya	[illegible]	Ha'tla'lkm	Cejptsa	Pak.etan	Tqoat'ək C'n	La'ket	Nqa'tl'markan	Kula'ta
Locality	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar	Utamqt of North Bend and Boston Bar
[illegible]			12	12	1	15	18	21	[illegible]	1	[illegible]		[illegible]	45	18	30	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
[illegible]	1,116	1,053	1,180	1,023	-	1,243	1,320	1,260	1,407	1,372	1,340	1,363	1,351	[illegible]	1,332	1,285	1,214	1,216	1,278	1,360	1,292	1,280	[illegible]	1,313	
[illegible]	674	551	[illegible]	[illegible]		689	[illegible]	720	746	633	724	725	745	748	744	691	664	[illegible]	682	713	760	672	741	716	
[illegible]	1,302	1,242	1,432	1,324		1,573	1,728	1,681	[illegible]	1,773	1,710		1,761	1,708	1,760		1,524	1,510	1,610	1,745	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	725	707	775	714	714	823	897	862	905	933	874	873	903	847	863	843	765	790	830	616	808	797	843	815	793
[illegible]	[illegible]	250	319	243	312	324	377	[illegible]	408	407	354	363	377	362	375	381	311	327	365	364	[illegible]	374	348	361	348
[illegible]	177	180	177	175	170	182	181	183	186	194	190	185	188	184	189	191	189	177	195	188	[illegible]	182	185	176	185
[illegible]	148·5	150	152	153	156	148	158	159	156	165	165	157	156	164	161	160	158	151	155	162	160	151	154	156	160
[illegible]	[illegible]	[illegible]	[illegible]	101	112	116	117	[illegible]	[illegible]	121	140	116	120	121	120	117	117	[illegible]	[illegible]	118	124	[illegible]	[illegible]	[illegible]	117
[illegible]	130	130	131	135	133	136	112	149	148	148	151	150	161·5	148	154	154	143	139	149	153	160	148	144	146	153
[illegible]	42	43	45	45	47	52	54	53	48	51	62	50	55	52	54	47	53	53	55	47	55	51	56	62	57
[illegible]	35	35	34	33	[illegible]	38	[illegible]	37	[illegible]	41	34	36	40	[illegible]	[illegible]	40	40	41	40	41	43	38	40	[illegible]	43
[illegible]	[illegible]	[illegible]	85·9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85·1	86·8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	83·6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	85·1
[illegible]	81·5	79·3	81·7	74·8	84·2	85·4	82·4	81·9	81·1	81·8	92·7	77·3	79·5	81·8	77·9	76·0	81·8	79·1	87·3	77·1	82·7	81·8	90·9	79·0	76·5
[illegible]	83·3	81·1	75·6	77·8	70·2	73·1	71·6	69·8	79·2	80·4	54·8	72·0	72·7	75·0	74·1	85·1	75·5	77·4	72·7	67·2	78·2	71·5	71·1	[illegible]	75·4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	43·2	44·1	[illegible]	[illegible]	[illegible]	[illegible]	44·6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—
[illegible]	101·6	99·4	[illegible]	[illegible]		[illegible]	105·1	[illegible]	[illegible]	103·7	104·3		104·2	106·1	[illegible]		[illegible]	[illegible]	[illegible]	107·7	[illegible]	100·8		[illegible]	—
[illegible]	52·8	54·1	54·4	55·4		[illegible]	[illegible]	54·6	[illegible]	51·6	[illegible]	[illegible]	[illegible]	52·6	52·6	[illegible]	51·7	[illegible]	[illegible]	[illegible]	51·5	51·8	[illegible]	51·9	—
[illegible]	[illegible]	[illegible]	[illegible]	22·7		21·2	[illegible]	[illegible]	[illegible]	21·8	23·4	21·7	22·3	22·5	22·9	21·6	21·0	[illegible]	[illegible]	22·5	21·3	[illegible]	21·5	[illegible]	-

[1] Father of Nos. 16, 17, and 18. [2] Mother of half-bloods Nos. 2, 4, and 18. [3] Son of No. 10; brother of Nos. 17 and 18. [4] Son of No. 10; brother of Nos. 16 and 18. [5] Son of No. 10; brother of Nos. 16 and 17. [6] Son of Nos. 39 and 60. [7] Son of No. 42. [8] Grandson of No. 42. [9] Brother of No. 28. [10] Brother of No. [illegible]. [11] Son of No. 69; brother of No. 51. [12] Father of No. 2[illegible]. [13] Father of No. 21.

72	96	9[illegible]	
Nakwî'nak	Yîlla's	[illegible]	
Utamk·t of North Bend and Boston Bar	Ntlakyapamuq'ō'ē		
55	28		
mm[illegible]	mm.	[illegible]	
1,45[illegible]	1,673[36]	1[illegible]	
1,20[illegible]	1,382	1	
62[illegible]	747		
—	1,760	1	
75[illegible]	841		
30[illegible]	381		
18[illegible]	186		
14[illegible]	157		
10[illegible]	127		
13[illegible]	144		
4[illegible]	50		
4[illegible]	38		
79·[illegible]	84·4		
76·[illegible]	88·2		
88·[illegible]	76·0		
43·[illegible]	44·7		
—	105·4		
51·[illegible]	50·4		
20·[illegible]	22·8		

Nos. 54 [illegible]
No. 13 [illegible]
er of N[illegible]

Nos. 80 a[illegible]
[35] S[illegible]

c. *Upper Utamk't of Boston Bar and North Bend* (continued)

II. Females

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
[illegible]	[illegible]	[illegible]	Mary M[illegible]	Cort[illegible]	W[illegible]	[illegible]	K[illegible]	Ma[illegible]	Pi'x[illegible]	Cecilia	K'ustik'tla	Yë'tlwnt	K'ustuqua'tgo	Oli'm'tgo	Kuspa'lgo	Tulo'	Ctlalwhua'k	Qitlpë'tgo	Mary Ntaqen'luna	Kastlaisis	Nakwi'uak	Tla'ma	Tsesa'ts
[illegible]	[illegible]	[illegible]	[illegible]	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar	Utamk't of North Bend and Boston Bar
4	5	6	6	9	10	11	11	11	19	24	24	25	26	30	30	32	38	40	40	42	55	60	60
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
		[illegible]	[illegible]	1,[illegible]	1,[illegible]6	1,310	1,366	1,447	1,527	1,548	1,591	1,565	1,602	1,504	1,593	1,527	1,568	1,485	1,450	1,5[illegible]	1,1[illegible]	1,0[illegible]	—
		8[illegible]4	853	1,013	1,060	1,063	1,130	1,165	1,247	1,253	1,313	1,280	1,290	1,206	1,326	1,247	1,230	1,200	1,170	1,320	1,202	1,215	—
		[illegible]	11	526	571	554	599	642	651	671	683	710	669	672	712	669	616	623	619	[illegible]	[illegible]	678	—
		[illegible]	1,[illegible]	1,318	1,345	1,323	1,403	1,451	1,612	1,680	1,609	1,577	1,621	1,583	1,662	1,570	1,618	1,711	1,469	1,[illegible]8	—	1,600	
		560	627	653	708	715	732	760	816	834	861	827	895	830	870	828	799	804	787	785	756	797	750
		246	240	268	283	285	320	315	353	337	336	3[illegible]3	378	348	316	341	332	337	316	344	300	[illegible]	301
		165	164	168	169	151	172	171	184	182	180	179	185	176	163	173	178	181	176	188	183	176	184
		151	146	150	163	142	144	155	156	151	166	164	160	146	146	168	153	140	151	151	145	149	153
		92	91	97	93	93	98	106	112	107	119	119	116	110	116	110	109	119	107	110	104	108	110
		123	119	120	128	124	128.5	131	141	140	146	141	143	134	117	117	144	131	135	110	110	136	141
		[illegible]	39	40	37	40	41	43	44	45	51	47	48	44	48	48	44	44	48	52	45	46	54
			30	29	32	28	32	35	34	35	37	34	37	32	33	34	37	34	33	36	40	42	42
		[illegible]	[illegible]	[illegible]	[illegible]	94.1	83.7	80.6	85.1	81.0	86.7	86.0	81.1	62.9	86.4	91.3	86.0	80.7	86.8	81.4	79.2	84.7	83.2
		76.[illegible]	[illegible]	77.[illegible]	72.7	75.0	76.6	80.9	79.5	82.[illegible]	81.5	64.4	81.1	82.1	81.7	80.3	76.7	88.8	75.[illegible]	76.5	76.5	79.4	76.1
		[illegible]	[illegible]	75.[illegible]	80.5	70.0	78.0	81.4	77.3	77.8	72.5	72.4	77.1	72.7	68.8	70.8	84.1	77.3	68.8	6[illegible]	88.[illegible]	91.3	79.2
		[illegible]	40.5	41.7	43.1	42.3	43.1	44.3	42.6	42.9	43.0	47.3	41.8	44.8	44.8	43.7	42.7	42.1	44.3	44.6	43.1	41.3	—
		[illegible]	97.1	[illegible]	101.1	101.0	101.0	100.0	98.8	102.6	101.2	102.6	101.3	105.6	105.9	102.6	100.7	102.1	102.7	107.2	—	102.6	—
		57.7	57.5	54.2	56.2	54.6	52.7	62.1	65.3	64.2	54.2	55.1	55.9	55.3	54.7	54.1	62.9	64.3	55.1	50.0	51.8	52.4	—
		[illegible]	[illegible]	22.[illegible]	21.3	21.8	23.0	21.7	23.1	21.9	21.1	22.2	22.4	22.5	19.9	22.3	22.0	22.8	22.0	21.0	20.5	21.8	—

d. *Utamk't and Ntlakyapamuq'ö'ë mixed*

Females

75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
Utlqoia'stnak	Tuk wi'nak	Pqa'otgo	Tstota'tgo	Tsek'ak'u'nak	K'sa'us	K'ë'tgo	Ape	Tlopa'ut	Ka'pa	Tommy	Jimmy	Stephen Ma'tletc	K'ilik'a'lan	E'tail	Pi[illegible]	Ca'ella	Tahelst	Kwa'mask'en	Tsalll'tinask't	Qoe'mskt
F Lytton; M ½ Boston Bar ½ Lytton	F Lytton; M ½ Boston Bar ½ Lytton	F North Bend; M Lytton	F Lytton; M ½ Boston Bar, ½ Lytton	F Lytton; M ½ Lytton, ½ North Bend	F ½ Lytton, ½ Boston Bar; M Boston Bar	F Lytton; M North Bend	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë
5	8	9	25	34	40	42	5	6	6	7–8	9	9	9	10	16	18	20	22	22	24
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1,020	1,2[illegible]	1,1[illegible]	1,5[illegible]	1,5[illegible]	1,535	1,516	1,[illegible]3	1,16[illegible]	1,153	1,210	1,128	1,305	1,267	1,270	1,583	1,[illegible]	1,707	1,726	1,654	1,688
777	968	916	1,310	1,257	1,272	1,253	812	840	914	955	902	1,047	1,012	1,017	1,293	1,390	1,398	1,400	1,370	1,402
413	501	4[illegible]5	688	627	656	481	414	472	499	476	502	555	478	462	685	760	738	776	733	772
1,021	1,200	1,134	1,610	1,580	1,525	1,580	[illegible]	1,101	1,153	1,204	1,151	1,313	1,266	—	1,606	1,790	1,751	1,822	1,746	1,783
561	672	633	844	812	826	786	612	610	617	692	600	705	687	613	803	904	898	892	895	878
246	257	2[illegible]5	345	348	342	313	225	249	258	260	268	285	273	273	[illegible]	[illegible]	402	376	395	384
161	160	171	174	187	189	178	184	168	172	172	170	177	182	174	177	184	187	186	192	192
143	145	141	152	156	147	151	150	161	153	158	141	154	143	151	150	159	148	161	158	156
90	97	102	121	120	108	108	93	97	95	97	94	102	102	102	115	122	119	118	121	125
120	131	118	148	147	141	139	120	128	127	131	126	134	127	129	137	143	157	153	143	118
33	39	40	47	45	50	50	37	37	47	34	40	37	46	43	50	48	50	50	51	50
31	34	31	32	34	40	34	28	30	31	32	32	39	33	31	37	37	32	38	33	36
88.8	80.[illegible]	82.5	87.1	83.4	77.8	84.9	91.5	95.8	89.3	91.9	81.0	87.0	78.6	87.3	84.7	86.4	79.1	86.6	82.3	81.3
75.0	74.0	86.1	87.7	81.6	76.6	77.7	77.5	75.8	74.8	74.0	74.6	76.1	80.[illegible]	79.1	83.8	85.9	86.9	77.1	84.6	84.5
91.9	87.2	77.5	68.4	76.6	81.0	68.0	75.7	81.1	83.8	94.1	80.0	105.0	71.7	72.1	74.0	77.1	64.0	76.0	64.7	72.0
40.5	40.7	40.4	43.3	43.0	42.8	43.9	43.2	42.9	43.4	39.4	41.4	42.7	42.1	36.4	43.4	44.7	43.2	44.8	44.1	45.7
100.0	97.6	98.6	101.3	103.3	99.0	101.9	100.0	100.0	100.0	99.5	101.8	101.0	100.0	—	101.6	105.3	102.4	105.3	105.8	105.5
55.0	54.6	55.0	53.1	54.1	51.6	50.7	4[illegible].4	55.5	53.7	57.2	53.1	54.2	54.1	48.3	50.8	53.2	52.5	51.6	54.3	52.0
23.1	20.9	23.1	21.1	22.7	21.6	20.2	21.9	22.6	22.4	21.5	23.7	21.9	21.5	21.5	21.5	20.8	23.5	21.7	21.9	22.7

e. *Ntlakyapamuq'ö'ë*

I. Males

96	97	98	99	100	101	102	103	104	[illegible]	[illegible]	107	108	109	110	111	[illegible]	[illegible]	114
Yilla's	Paul Tlo[illegible]	K[illegible]	Yo'la	Dabo'mtk'an	Silas N'CH	Ya'nlmakan	Ma'tsan	K'lakst	T[illegible]	[illegible]	Patpatk'a'tak'en	Quitk'ën	Ha'ko	Taa[illegible]	Tlao'tak'a	Qoz[illegible]k'an	[illegible]	Phil[illegible] Kina[illegible]
Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë	Ntlakyapamuq'ö'ë
28	28	[illegible]8	45	45	47	48	55	55	58	58	58	60	60	65	65	65	65	65
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1,[illegible]73	1,700	1,[illegible]5	1,630	1,[illegible]52	1,[illegible]	1,547	[illegible]	1,[illegible]	[illegible]	1,[illegible]	1,643	1,635	1,547	1,544	[illegible]	1,5[illegible]	1,[illegible]4	1,[illegible]
1,382	1,406	1,397	1,318	1,376	1,313	1,299	1,[illegible]	1,220	1,[illegible]7	1,370	1,312	1,341	1,273	1,290	—	1,287	1,413	1,328
747	784	772	725	767	710	677	7[illegible]	[illegible]	[illegible]	7[illegible]	691	711	701	707	—	[illegible]	766	704
1,76[illegible]	1,883	1,[illegible]77	1,[illegible]	1,765		1,[illegible]21	[illegible]	[illegible]	[illegible]	[illegible]	1,[illegible]56	1,742	1,648	1,6[illegible]	[illegible]	[illegible]	1,715	1,713
841	861	882	865	817	849	803	867	803	803	828	818	842	813	793	878	783	880	870
[illegible]81	[illegible]	370	[illegible]	378	370	[illegible]	[illegible]71	[illegible]	[illegible]	[illegible]	358	349	329	[illegible]65	[illegible]	341	365	372
186	189	184	181	184	192	180	187	179	185	186	187	191	196	197	189	180	183	190
157	157	151	162	155	155	155	149	150	153	148	160	148	151	153	158	146	150	146
127	120	118	115	118	125	117	123	119	119	110	116	117	125	128	115	120	120	125
141	144	117	147	147	144	145	148	149	—	149	140	144	148	147	154	139	148	145
50	51	54	63	55	58	55	54	52	53	50	52	53	56	61	48	59	52	52
38	41	37	42	38	40	36	39	39	—	42	35	40	39	39	42	38	41	46
81.4	8[illegible].1	82.1	89.5	84.2	80.7	86.1	79.7	[illegible]	82.7	[illegible]	80.2	77.5	77.0	77.7	83.6	81.1	82.0	76.8
88.2	82.2	80.3	78.2	80.3	8[illegible].8	80.7	83.1	85	—	7[illegible].8	79.5	81.2	84.5	87.1	74.7	86.3	81.1	86.2
71.0	80.4	68.5	72.2	69.1	69.0	65.5	72.2	75.0		84.0	67.3	75.5	69.6	63.9	87.5	64.4	78.8	86.5
41.7	46.1	46.0	41.5	45.9	41.8	43.7	[illegible]	46.0	44.1	43.8	43.2	43.6	45.2	45.9	[illegible]	45.0	45.6	42.9
105.4	110.8	105.4	105.7	106.4		101.7	101.7	108.4	102.6	103.2	103.5	106.9	106.3	104.6	103.2	104.2	103.9	104.4
[illegible]4	50.6	52.5	53.1	49.5	52.4	51.8	51.5	53.2	50.2	51.1	51.1	51.7	52.5	51.5	53.5	50.8	52.4	53.1
22.8	23.4	22.0	20.4	22.9	22.8	23.2	22.9	24.0	21.5	23.8	21.4	21.3	21.2	23.7	23.4	22.9	21.7	22.7

Footnotes: Daughter of No. 61, sister of No. 65. — Daughter of No. 61, sister of No. 64. — Mother of No. 23. — Mother of Nos. 54, 65. — Sister of No. 64. — Sister of No. 62. — Daughter of No. 74. — Mother of Nos. 31 and 35. — Mother of No. 67. — Daughter of Nos. 80 and 111, sister of Nos. 76 and 78. — Daughter of Nos. 80 and 111, sister of Nos. 75 and 78. — Daughter of No. 140. — [illegible] sister of Nos. 75 and 76. — Mother of No. 63. — Mother of Nos. 75, 76, and 78. — Son of Nos. 103 and 136; brother of No. 130. — Son of Nos. 76 and 101 (placed by mistake in this group). — Son of No. 139. — Son of No. 106; brother of No. 92. — Grandson of No. 146. — Son of No. 106, brother of No. 86. — Father of No. 120. — Father of No. 83. — Brother of No. 106. — Father of Nos. 82 and 130. — Father of Nos. 86 and 92; brother of No. 102. — Father of Nos. 75, 76, and 78. — Father of No. 153.

11. *Ntlaky*…

…*amuq'ō'ē* (conti…*q'ō'e and Upper Tribes mixed.*

	136	137	158	159	160	161	162	163	164	165	166
			II. Females								
	Hē'stgō	Wutlqa'	Ci'ntgō	Zehē'btsa	Kôtlgō'tlgō	Tculoqutcē'nak'	Kaqpī'tza	Mā'asūtl	Kuslaqī'nak	Kwazī'nik	K·ena'tgō
	Ntlakyapamuq'ō'ē	Ntlakyapamuq'ō'ē	F. Lytton M. Spence's Bridge	F. Lytton M. Foster Bar	F. Nicola Valley M. Lytton	F. Spence's Bridge M. Lytton	F. Okanagan M. Lytton	F. Lytton M. Nicola	Stlaqā'yuq	F. Lytton M. Spence's Bridge	Stlaqā'yuq
	32	35	17	19	29	30	33	37	37	39	40
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
	1,548[58]	1,505	533[71]	1,550[72]	1,422	1,534[73]	1,510[74]	1,556	1,558	1,540[75]	1,573[76]
	1,258	1,227	224	1,295	1,190	1,280	—	1,292	1,270	1,270	1,281
	674	682	650	580	663	650	—	665	658	683	689
	1,565	1,605	547	1,606	1,558	1,570	1,540	1,620	1,578	1,588	1,638
	812	777	792	817	764	794	—	820	837	837	839
	340	329	338	336	321	322	335	336	350	343	371
	174	179	179	178	171	173	174	172	180	181	178
	144	140	146	150	146	148	148	146	149	152	152
	108	119	112	111	108	111	119	113	122	114	110
	137	130	134	138	133	134	141	133	138	143	144
	42	53	49	39	47	44	47	49	50	46	45
	31	31	36	33	36	32	34	35	37	36	33
	9·7·8	78·2	81·6	84·3	85·4	85·8	85·1	84·9	82·8	84·0	85·4
	5·48	91·5	83·6	80·5	81·2	82·9	84·4	85·0	88·4	79·1	76·4
N	8·3	[illegible]	73·5	84·6	76·6	72·7	72·4	71·4	74·0	78·3	73·3
In	44·3	45·2	42·5	46·1	46·7	42·5	—	42·6	42·3	44·3	43·9
In	—	106·3	01·1	103·6	109·7	102·6	102·7	103·8	101·2	103·1	104·3
In	52·2	51·3	51·8	52·7	53·8	51·9	—	52·6	53·7	54·4	53·4
In	21·8	21·8	22·1	21·7	22·6	21.1	22·2	21·5	22·4	22·3	23·6

Dau No. 134 …ter of No. 129. [52] Grand-daughter of No. 106; sister
of 121. …other of Nos. 126 and 129. [63] Grandmother of No. 89;
No. 1[8] Son o… [73] Mother of No. 119. [74] Mother of No. 157.

II. Ntlakyapamuq (continued)

c. Ntlakyapamuq (continued). — I c. Females. / f. Ntlakyapamuq and Upper Tribes mixed: I. Males; II. Females.

Number	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
Name	Ma[illegible]la	[illegible]nak	Stekë'tsinak	[illegible]nak	Catherine	[illegible]	Mary	Stekü'k[illegible]	Qaë'nak	Waia'[illegible]go	Qëtlgu'tgo	Pauline	[illegible]tsko	C[illegible]go	Mariann[illegible]	[illegible]tcëk[illegible]nak	K[illegible]ma'tgo	Ca[illegible]nak	Kaltlua'tgo	[illegible]tlgo	Qaspë'tsa	[illegible]go	Wat[illegible]	St'qut qt'a'tgo	[illegible]	Mtdy White mixed
Tribe	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö
Age	3	6	6	9	10	10	11	12	15	1[illegible]	16	16	16	18	18	18	19	19	28	30	30	[illegible]	35	36	41	41
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
[illegible] (7 rows of body measurements)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Length of head	166	1[illegible]8	179	176	166	17[illegible]	1[illegible]9	175	173	177	178	170	17[illegible]	[illegible]8	176	18[illegible]	172	17[illegible]	181	188	1[illegible]	171	171	178	181	182
Breadth of head	14[illegible]	11[illegible]	[illegible]	14[illegible]	148	145	141	14[illegible]	152	150	141	151	144	148	150	147	15[illegible]	17[illegible]	1[illegible]	147	1[illegible]	144	14[illegible]	118	11[illegible]	[illegible]16
Breadth of face	85	92	93	97	97	101	102	107	105	100	107	107	105	[illegible]	[illegible]	105	11[illegible]	1[illegible]	110	117	117	108	1[illegible]	11[illegible]	11[illegible]	112
Height of face	130	122	12[illegible]	1[illegible]5	12[illegible]	[illegible]	128	1[illegible]1	131	128	131	1[illegible]	131	1[illegible]1	1[illegible]2	131	115	11[illegible]	138	131	117	137	1[illegible]	11[illegible]	127	[illegible]
Height of nose	31	[illegible]8	18	37	46	41	42	45	46	42	41	30	42	46	35	14	52	16	15	19	41	42	[illegible]		51	50
Breadth of nose	25	2[illegible]	29	31	34	[illegible]	[illegible]	44	46	36	32	7	35	5	1[illegible]	[illegible]1	3[illegible]	[illegible]7	11	4	[illegible]	31	31	35	[illegible]	35
Length-breadth index	8[illegible]	84	86.8	84.7	84.2	81.8	85.2	81.7	87.9	84.7	83.9	88.8	81.2	8[illegible]	80.4	80.6	87.8	86.6	8[illegible].6	78.2	7[illegible].7	82.5	78.2	81.1	77.[illegible]	8[illegible].2
Facial index	76.3	75.1	76.4	77.[illegible]	78.[illegible]	8[illegible]	79.7	79.9	78.3	78.1	81.7	79.3	78.[illegible]	79.7	74.2	76.[illegible]	83.7	81.5	76.7	87.[illegible]	7[illegible].1	78.8	[illegible]1.5	81.1	89.0	7[illegible]
Nasal index	80.6	76.[illegible]	76.3	91.[illegible]	85.0	75.6	78.6	7[illegible]	78.3	85.7	80.0	[illegible]9	83.3	7[illegible].1	[illegible]	70.5	67.[illegible]	80.[illegible]	7[illegible].3	69.1	78.[illegible]	71.8	6[illegible]	77.8	68.6	70.0
Index of [illegible]		41.1	41.1	41.4	42.6	41.1	40.2	41.1	44.8	46.1	43.9	45.2	43.0	41.1	41.2	42.6	43.[illegible]	45.[illegible]	42.6	44.2	44.[illegible]	43.5	47.2	44.3	4[illegible].6	42.6
Index of span	93.4	106.[illegible]	100.[illegible]	99.0	99.6	100.8	98.4	102.2	103.4	105.8	101.8	105.7	100.6	1[illegible]1.2	97.0	101.[illegible]	101.[illegible]	1[illegible]2.5	101.0	102.2		[illegible]1.5	106.[illegible]	10[illegible].2	93.1	101.6
Index of height sitting	78.0	55.1	51.0	51.6	53.[illegible]	53.8	51.5	5[illegible].1	51.6	48.2	51.2	51.0	51.2	51.5	53.9	51.0	50.9	5[illegible]	52.6	52.7	52.2	52.4	[illegible]1.3	[illegible]3.6	51.9	51.4
Index of width of shoulders	—	21.8	22.3	21.0	23.1	20.2	20.9	22.1	19.5	21.5	20.8	21.0	21.9	22.0	21.2	22.0	22.0	22.6	22.7	21.1	21.8	21.9	21.8	21.3	20.2	21.4

Number	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
Name	C[illegible]mat'go	K'osk'[illegible]tgo	K'oei[illegible]tgo	Gatpa'tgo	Gwa'tlgo	Sëlpe'nak	Ma[illegible]ma'q'go	Na'natlgo	Tsö[illegible]	Kos[illegible]'nak	K'oe'tsa	George	Kok'taya'll	Yë'tamuq	S[illegible]	Te[illegible]	[illegible]	[illegible]	Alh[illegible]	K[illegible]tlgo	[illegible] Qotce'nak	Kapi'tsa	[illegible]	Koolu[illegible]'nak	Kw[illegible]nak	K[illegible]
Tribe	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	Ntlakyapamuqö	F. Lytton; M. [illegible]	F. Lytton; M. [illegible] Spences Bridge	F. [illegible] Spences Bridge [illegible]	F. Spences Bridge [illegible]	F. Spences [illegible]	F. Lytton; M. [illegible]	F. Lytton; M. Spences Bridge	F. [illegible]; M. [illegible]	F. [illegible]; M. [illegible]	F. Spences [illegible]; M. [illegible]	F. [illegible]; M. Lytton	F. [illegible]; M. [illegible]	Ntlakyapamuq	F. Lytton; M. Spences Bridge	Ntlakyapamuq
Age	43	52	53	55	55	55	58	60	60	6[illegible]	75	11	13	10	42	70	8	17	19	19	30	33	37	37	33	41
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
[illegible] (7 rows of body measurements)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Length of head	170	171	18[illegible]	18[illegible]	[illegible]1	184	18[illegible]	186	179	18[illegible]	189	183	17[illegible]	183	181	191	172	17[illegible]	1[illegible]8	17[illegible]	17[illegible]	17[illegible]	172	180	181	17[illegible]
Breadth of head	141	172	117	1[illegible]	1[illegible]	148	112	152	147	1[illegible]	118	1[illegible]	14[illegible]	182	1[illegible]8	160	147	1[illegible]7	150	[illegible]46	148	148	146	149	152	1[illegible]2
Breadth of face	1[illegible]5	12[illegible]	111	1[illegible]4	112	110	10[illegible]	116	10[illegible]	1[illegible]	11[illegible]	105	1[illegible]2	1[illegible]8	12[illegible]	1[illegible]	[illegible]3	1[illegible]	11[illegible]	1[illegible]8	111	11[illegible]	113	12[illegible]	111	110
Height of face	13[illegible]	[illegible]41	14[illegible]	1[illegible]2	1[illegible]8	130	[illegible]3	135	1[illegible]1	136	11	131	136	1[illegible]3	11[illegible]	14[illegible]	121	1[illegible]	1[illegible]8	13[illegible]	134	111	13[illegible]	138	11[illegible]	111
Height of nose	4[illegible]	50	47	[illegible]0	4[illegible]	49	51	52	47	[illegible]3	51	42	36	18	4[illegible]	[illegible]8	39	4[illegible]	3[illegible]	47	14	47	49	50	46	45
Breadth of nose	1[illegible]	6	[illegible]8	47	[illegible]8	40	[illegible]2	35	[illegible]8	37	41	3	[illegible]8	[illegible]8	5	10	31	[illegible]	3	36	2	34	[illegible]7	37	36	3[illegible]
Length-breadth index	84.7	8[illegible].3	79.1	77.7	84.0	8[illegible].4	75.5	81.7	82.1	8[illegible].1	78.1	8[illegible].6	81.2	88.5	8[illegible].1	8[illegible]	85.5	81.[illegible]	81.3	8[illegible].4	8[illegible].8	85.1	84.9	82.3	81.0	85.4
Facial index	77.8	8[illegible].1	75.2	6[illegible].4	81.2	81.6	79.1	85.9	80.6	81.6	79.0	8[illegible].2	75.[illegible]	70.6	81.1	8[illegible].9	76.9	8[illegible]	80.5	81.2	82.9	61.4	85.0	88.4	79.1	76.4
Nasal index	76.7	72.0	8[illegible].9	74.0	77.6	81.6	62.7	67.8	80.9	6[illegible].8	75.9	78.3	106.0	79.2	79.6	61.0	73.5	73.5	81.0	76.6	72.7	72.4	71.4	74.0	78.3	73.3
Index of [illegible]	42.3	42.[illegible]	43.8	46.1	4[illegible]	42.8	43.1	44.2	44.9	[illegible]	45.5	44.0	44.0	44.2	44.1		—	42.5	46.1	46.7	42.5	—	42.6	42.3	44.3	43.9
Index of span	101.6	103.5	103.2	10[illegible].8	99.1	102.8	101.1	1[illegible]2.7		101.[illegible]	102.6	102.3	103.0	106.6	10[illegible]		102.2	101.1	1[illegible]3.6	10[illegible].7	102.6	102.7	103.8	101.2	107.1	101.3
Index of height sitting	5[illegible]	5[illegible].4	52.3	50.6	51.0	52.5	51.2	51.4	51.5	52.9	50.5	52.7	51.4	51.2	55.0	—	—	51.8	52.7	53.8	51.9	—	52.6	53.7	54.[illegible]	53.4
Index of width of shoulders	21.[illegible]	22.2	22.5	21.4	2[illegible].1	21.0	23.0	22.1	21.2	21.6	22.1	21.9	22.8	24.8	21.0		21.8	22.1	21.7	22.6	21.1	22.2	21.5	22.4	22.3	23.6

[illegible] Grand-daughter of No. 106, sister of Nos. 126 and 127, twin sister of No. 125. [illegible] Sister of No. 118. [illegible] Sister of No. 117. [illegible] Daughter of No. 161. [illegible] Daughter of No. 96. [illegible] Daughter of No. 1[illegible]4. [illegible] Sister of No. 1[illegible]8. [illegible] Grand-daughter of No. 106, sister of No. 116, twin sister of No. 127. [illegible] Grand-daughter of No. 143, sister of No. 129. [illegible] Grand-daughter of No. 106, sister of No. 116, twin sister of No. 125. [illegible] Sister of No. 122. [illegible] Sister of No. 126. [illegible] Daughter of Nos. 103 and 136; sister of No. 82. [illegible] Sister of No. 85. [illegible] Father of 121. [illegible] Mother of Nos. 82 and 130. [illegible] Mother of half-blood No. 17. [illegible] Daughter of No. 148. [illegible] Daughter of No. 77. [illegible] Grandmother of Nos. 126 and 129. [illegible] Grandmother of No. 89, daughter of No. 151. [illegible] Mother of No. 130. [illegible] Mother of No. 146; great-grandmother of No. 89. [illegible] Son of No. 166, brother of No. 159. [illegible] Son of No. 116. [illegible] Son of No. 156. [illegible] Father of No. 155. [illegible] Daughter of No. 162. [illegible] Sister of No. 165. [illegible] Daughter of No. 166; sister of No. 152. [illegible] Mother of No. 119. [illegible] Mother of No. 157. [illegible] Sister of No. 158. [illegible] Mother of Nos. 152 and 160.

a (conti

87	18
Tkutli'qk'en	Kunkuná'mtqa
Nkamtci'nEmuQ	Nkamtci'nEmuQ
6	1
nm.	m
08[89]	1,5
87	1,2
64	6
75	1,5
13	8
58	3
62	1
51	1
13	1
26	1
42	
30	
3·2	8
9·7	8
1·4	7
1·8	4
6·9	10
5·2	5
3·2	2

2.
ood No.

g. Nkamtci'nEmuq

Number	167	168	169	170	171	172	173	174	175	176	177
	I. Males										
Name	Kiyu'l'ma	Qö[illegible]	Nawawaqkt	Kikä'les	Thomas Ka[illegible]m	Koe'tsan	Lsaisi'tsam	Quatamtn'tsa	Keltin'tsa	Gu'atl[illegible]	Te'k'a
Tribe	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq
Age	7	21	25	25	29	30	33	38	40	50	50
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	[illegible]	[illegible]	1,674	1,710	[illegible]	[illegible]	[illegible]	1,615	1,660	1,544	[illegible]
Height of shoulder	[illegible]	[illegible]	1,369	[illegible]	[illegible]	1,246	1,300	1,372	1,318	1,228	1,35[illegible]
Length of arm	[illegible]	[illegible]	776	779	[illegible]	711	707	749	745	[illegible]	[illegible]
Finger reach	[illegible]	[illegible]	1,708	1,828	[illegible]	—	1,660	1,708	[illegible]	1,601	[illegible]
Height sitting	[illegible]	[illegible]	887	898	878	823	[illegible]	842	861	810	812
Width of shoulders	[illegible]	[illegible]	385	[illegible]	410	363	374	[illegible]82	371	[illegible]69	341
Length of head	17[illegible]	202	187	195	191	186	190	179	187	197	181
Breadth of head	1[illegible]	1[illegible]2	1[illegible]	160	16[illegible]	155	161	153	151	158	148
Height of face	[illegible]	1[illegible]5	118	1[illegible]	124	110	116	129	1[illegible]0	125	111
Breadth of face	[illegible]	1[illegible]1	151	149	148	143	144	143	147	1[illegible]	1[illegible]
Height of nose	[illegible]	[illegible]	51	53	[illegible]	48	52	56	52	54	52
Breadth of nose	[illegible]	41	[illegible]	36	45	40	38	36	37	41	41
Length-breadth index	[illegible]	8[illegible]2	81.8	82.1	84.3	83.3	79.5	85.5	81.8	80.2	81.8
Facial index	72.6	89.1	78.1	87.9	[illegible]	76.9	80.6	90.2	81.6	80.6	85.1
Nasal index	[illegible]	74.[illegible]	74.5	67.9	70.0	83.[illegible]	75.1	62.5	71.2	77.1	78.8
Index of arm	41.7	45.2	45.3	45.[illegible]	41.7	44.5	45.3	46.4	4[illegible].1	45.6	43.9
Index of finger reach	10[illegible]	100.[illegible]	105.[illegible]	106.3	104.2		106.4	101.5	101.5	10[illegible].0	103.2
Index of height sitting	5[illegible]	50.1	51.[illegible]	52.2	51.2	[illegible]	53.4	51.0	52.0	53.6	52.[illegible]
Index of width of shoulders	[illegible]	22.1	21.1	22.8	21.8	22.7	21.0	23.2	22.3	24.4	21.3

Number	178	179	180	181	182	183	184	185	186	187	188
	I. Males								II. Females		
Name	Wotjo'lst	Kwatce'ta'	Kolomaste't	Nkamo'lt	Ta'qsa	Yi'lgoska	Tluqpä'os	TeliEqö'sket	Tlemaq,ana'lgö	[illegible]k en	Kinkan[illegible]'gö
Tribe	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq
Age	51	54	55	59	65–70	70	75	95	5	6	16
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	1,70[illegible]	[illegible]	1,7[illegible]5	[illegible]	[illegible]	[illegible]	1,540	[illegible]	[illegible]	[illegible]	[illegible]
Height of shoulder	1,400	1,384	1,362	1,353	1,311		1,246	—	850	887	[illegible]
Length of arm	777	[illegible]	770	751	[illegible]		[illegible]86	—	[illegible]	[illegible]	[illegible]
Finger reach	[illegible]	1,686	1,810	1,774	1,72[illegible]	—	[illegible]614	—	1,042	[illegible]	[illegible]
Height sitting	876	[illegible]	[illegible]	874	[illegible]		773	—	[illegible]	[illegible]	[illegible]
Width of shoulders	[illegible]	[illegible]	371	380	[illegible]		[illegible]41		[illegible]25	[illegible]	354
Length of head	190	181	187	198	185	186	188	189	161	[illegible]	18[illegible]
Breadth of head	1[illegible]	152	151	151	158	1[illegible]1	156	158	1[illegible]8	151	174
Height of face	128	115	122	118	119	121	115	101	90	113	118
Breadth of face	148	145	148	145	146	150	149	141	116	12[illegible]	1[illegible]6
Height of nose	55	49	[illegible]4	48	50	[illegible]	55	52	37	42	45
Breadth of nose	3[illegible]	40	[illegible]5	[illegible]	[illegible]8	[illegible]	40	41	31	[illegible]0	[illegible]5
Length-breadth index	78.9	84.0	80.7	76.3	85.4	86.6	[illegible]	83.6	86.0	[illegible]	[illegible]7
Facial index	86.5	79.3	82.4	81.4	81.5	82.0	77.2	70.1	77.6	[illegible]	86.8
Nasal index	65.5	81.6	70.4	75.0	63.3	[illegible]	72.7	78.8	83.8	71.4	77.8
Index of arm	45.7	43.9	46.4	45.2	47.7		41.5		41.8	41.8	4[illegible].8
Index of finger reach	107.6	101.5	10[illegible]	10[illegible]	107.8		[illegible]	—	98.1	[illegible]	100.0
Index of height sitting	51.5	51.9	50.[illegible]	52.7	[illegible]		50.2		56.5	[illegible]	52.6
Index of width of shoulders	2[illegible].1	20.4	22.[illegible]	22.9	22.6		22.2	—	21.4	21.[illegible]	22.7

Number	189	190	191	192	193	194	195	196	197	198	199
	II. Females										
Name	Qoza[illegible]'t'nk	Coasatö'lgö	Stcak[illegible]e'ock	Tak[illegible]m	Tul'a'nck [illegible]ap'lgö	Conuq[illegible]lgö	Qoa'ska	Ziwezl[illegible]tsa	Wast'nak	Tit'gö	Lei'tgö
Tribe	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq	Nkamtci'nEmuq
Age	17	19	32	35	37	40	48	52	60	68	70
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	1,[illegible]12	1,612	1,57[illegible]	1,555	[illegible]	[illegible]	1,733	[illegible]	1,470	[illegible]	[illegible]
Height of shoulder	[illegible]	[illegible]	1,307	1,295	1,314	1,300	1,265	1,272	1,204	1,226	[illegible]
Length of arm	[illegible]	705	[illegible]	[illegible]68	687	720	679	642	[illegible]	655	[illegible]
Finger reach	[illegible]	1,647	[illegible]	1,585	[illegible]	1,688	1,673	[illegible]	1,571	[illegible]	[illegible]
Height sitting	823	557	818	794	[illegible]	832	[illegible]	780	754	716	788
Width of shoulders	[illegible]	[illegible]	[illegible]	347	371	[illegible]	323	[illegible]	312	[illegible]	[illegible]
Length of head	185	174	178	189	180	178	183	17[illegible]	186	179	18[illegible]
Breadth of head	149	148	148	144	15[illegible]	144	145	148	148	142	143
Height of face	118	119	116	114	110	117	109	116	108	115	98
Breadth of face	1[illegible]	13[illegible]	[illegible]34	136	145	1[illegible]8	133	135	140	135	138
Height of nose	47	47	47	49	[illegible]	[illegible]	50	50	46	54	48
Breadth of nose	[illegible]	36	39	40	39	30	40	40	36	40	45
Length-breadth index	80.5	85.1	83.1	76.2	85.0	80.9	79.2	82.7	79.6	79.3	79.7
Facial index	90.8	88.1	82.1	83.8	75.9	84.8	82.0	85.9	83.1	85.2	71.0
Nasal index	72.4	7[illegible].6	81.0	81.6	79.6	54.5	80.0	80.0	78.3	74.1	93.8
Index of arm	46.1	45.8	4[illegible]	44.1	43.2	45.0	44.1	42.2	45.5	44.3	[illegible]
Index of finger reach	10[illegible]	10[illegible]	10[illegible]	101.6	105.7	105.5	10[illegible]	10[illegible]	106.9	102.0	104.8
Index of height sitting	[illegible]	53.2	5[illegible].8	50.8	5[illegible]	52.0	51.3	51.3	51.3	48.4	51.8
Index of width of shoulders	22.7	20.4	21.0	22.2	23.3	[illegible]	21.0	22.6	21.2	22.1	21.3

h. Nkamtci'nEmuq mixed with Shuswap and Okanagan

Number	200	201	202	203	204	205	206	207	208
	I. Males				II. Females				
Name	K[illegible]zail'skEt	Sa'tqEn	Paa	Te'e'a	A'nlgö	Tsakz[illegible]tza	Tuthit'nak	Quak'nak	Wa[illegible]lgö
Tribe	F. Nkamtci'nEmuq; M. ½ Nkamtci'nEmuq, ½ SEQ[illegible]	F. Okanagan; M. Nkamtci'nEmuq	F. SEQuapmuq; M. Nkamtci'nEmuq	F. Nkamtci'nEmuq; M. ½ Okanagan, ½ Nkamtci'nEmuq	F. ½ Nkamtci'nEmuq, ½ SEQuapmuq; M. Nkamtci'nEmuq	F. Okanagan; M. Nkamtci'nEmuq	F. Okanagan; M. Nkamtci'nEmuq	F. ½ SEQuapmuq, ½ Nkamtci'nEmuq; M. Nkamtci'nEmuq	F. Nkamtci'nEmuq; M. ½ SEQuapmuq, ½ Nkamtci'nEmuq
Age	49	60	75	6	26	50	50	53	65
	mm	mm	mm	mm	mm	mm	mm	mm	mm
Height standing	1,718	1,604	1,600	1,101	[illegible]	[illegible]	1,611	[illegible]	1,4[illegible]4
Height of shoulder	1,383	1,324	1,327	893	1,273	1,297	1,321	1,297	1,178
Length of arm	758	726	719	493	[illegible]62	707	687	678	636
Finger reach	1,798	[illegible]	[illegible]	1,113	1,571	[illegible]	1,635	1,575	1,490
Height sitting	900	836	832	616	801	853	837	840	72[illegible]
Width of shoulders	356	350	337	229	[illegible]	[illegible]	325	333	321
Length of head	187	184	187	167	183	1[illegible]	172	177	178
Breadth of head	150	150	156	143	144	147	147	142	150
Height of face	114	114	107	92	121	113	113	110	102
Breadth of face	146	147	151	122	136	13[illegible]	135	140	143
Height of nose	48	53	56	[illegible]5	47	49	[illegible]	43	48
Breadth of nose	38	40	42	29	37	36	31	35	37
Length-breadth index	80.2	77.3	83.4	85.6	78.7	77.0	85.5	85.9	84.3
Facial index	78.1	77.6	70.9	75.4	8[illegible].0	80.6	83.7	84.6	71.3
Nasal index	79.2	75.5	75.0	76.3	78.7	73.5	66.7	81.4	77.1
Index of arm	44.1	45.3	45.0	44.8	43.3	44.2	42.7	43.6	44.8
Index of finger reach	104.5	105.2	103.0	101.2	102.7	105.0	101.6	101.0	104.9
Index of height sitting	52.3	52.3	52.0	56.0	5[illegible].4	53.3	52.0	53.8	51.1
Index of width of shoulders	22.6	21.9	21.1	20.6	21.4	22.2	20.2	21.3	22.6

Son of Nos. 17[illegible] and 207. Brother of No. 170. Son of No. 197, brother of No. 175. Brother of No. 168. Brother of No. 173. Brother of No. 172. Son of No. 198. Son of No. 197, brother of No. 169. Father of No. 187. Father of No. 167. Father of No. 188.
Daughter of No. 192. Daughter of No. 178. Daughter of No. 184. Mother of No. 186, and of half blood No. 5. Mother of Nos. 169 and 175. Mother of No. 174. Mother of No. 167.

nales		II. Fema			13. *Okanagan.* Male	II. Females		13A. *Half-blood Okanagan.* Males	
17	1	19	20	21	1	2	3	1	2
Rosie	Rachel Oppenheim	Rosalie Daniel	Augustine Enoch	Julie Célestin	Allen Edward	Julienne François Shiletza	Victoire	Simon Kamloops	Edward Moreno
F. French M. Ntlakyapamuq'ō'e	F. German Jew	Sequā'pamuq (Kamloops)	Sequā'pamuq (Chukchukwulk)	Sequā'pamuq (Chukchukwulk)	Okanagan	Okanagan	Okanagan	F. White M. Okanagan	F. ½ Mexican, ½ Okanagan M. Okanagan
16	2	11	12	13	12	12	18	11	11
mm. 1,643	m 1,5	mm. 1,376	mm. 1,340	mm. 1,437	mm. ,352	mm. 1,354	mm. 1,552	mm. 1,355	mm. 1,270
1,367	1,2	1,112	1,092	1,158	,103	1,103	1,284	1,087	999
743	7	628	612	615	590	610	710	600	542
1,704	1,6	1,466	1,409	1,484	,380	1,396	1,623	1,369	1,262
847	8	752	747	822	733	740	820	738	708
348	3	315	305	296	297	302	350	288	281
173	1	179	176	179	179	174	188	177	183
146	1	148	142	151	150	150	147	145	143
112	1	109	106	118	111	99	110	97	103
131	1	128	129	134	134	131	140	126	123
44	4	46	45	44	43	41	43	41	44
34	3	34	32	34	32	29	33	30	34
84·4	85	82·7	80·7	84·4	3·8	86·2	78·2	81·9	78·1
85·5	80	85·2	82·2	88·1	2·8	75·6	84·6	77·0	83·7
77·3	68	73·9	71·1	77·3	4·4	70·7	76·7	73·2	77·3
45·3	45·	45·5	45·7	42·7	3·7	45·2	45·8	44·1	42·7
03·9	104·	06·2	105·1	103·1	2·2	103·4	104·7	100·7	99·4
51·6	53·	54·5	55·7	57·1	4·3	54·8	52·9	54·3	55·8
21·2	20·	22·8	22·8	20·6	2·0	22·4	22·6	21·2	22·1

ther of N

[6] Daughter of

11. *Ntlakya'pamuq* (continued)

i. *Half-blood Ntlakya'pamuq.*

I. Males												II. Females							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
[illegible]	[illegible]	[illegible] Duncan	David Oppenheim	[illegible] Walker	Jimmy William	Jimmy	Ka'ō	George	Willy Michel	William Hines	Jimmy Duncan	Annie Duncan	Louise Duncan	Hanna Igō	K'ilat'igō	Rosie	Rachael Oppenheim	Tenaise Igō Duncan	Mrs. Michel
[illegible]	[illegible]	F and M ½ Ntlakya'pamuq ½ White	F German Jew M Spuzzum	F Scotch M Ntlakya'pamuq	F White M Ntlakya'pamuq	F White M Nkamtci'nemuq	F American M Nkamtci'nemuq	F White M [illegible]	F Ntlakya'pamuq, ½ Spuzzum M ½ White, ½ Ntlakya'pamuq	F German M Ntlakya'pamuq ö'ô	F Scotch M Nkamtci'nemuq	F and M ½ Ntlakya'pamuq ½ White	F and M ½ Ntlakya'pamuq ½ White	F English M Nkamtci'nemuq	F White M Ntlakya'pamuq (?)	F French M Ntlakya'pamuq ö'ô	F German Jew M Spuzzum	F White M Ntlakya'pamuq ö'ô	F Scotch M Ntlakya'pamuq ö'ô
4		8	8	1	11	12	12	12	15	28	32	6	9	9	14	16	20	29	32
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
[illegible]	[illegible]	1,2[illegible]	1,204	1,321	1,743	1,[illegible]87	1,[illegible]16	1,362	1,615	1,691	1,654		1,210	1,301	1,188	1,643	1,584	1,572	1,601
	[illegible]	[illegible]	967	1,0[illegible]	1,102	1,045	1,058	1,106	1,466	1,483	1,464		944	1,0[illegible]9	970	1,367	1,284	1,308	1,300
—	429	628	617	694	615	571	656	601	723	757	744	—	476	544	500	743	714	658	666
—		[illegible]	1,184	1,37[illegible]	1,440	1,33[illegible]	1,316	1,3[illegible]	1,712	1,78[illegible]	1,750		1,200	1,300	1,176	1,701	1,618	1,544	1,596
[illegible]	730	673	672	690	690	688	698	728	871	875	808	538	653	710	631	847	842	887	861
[illegible]	[illegible]	[illegible]	257	263	291	266	296	311	337	395	394	266	268	281	267	348	326	317	332
177	178	174	178	165	173	176	178	184	178	190	195	165	169	173	168	173	176	180	181
141	144	152	146	151	150	145	163	154	160	155	156	138	142	148	139	146	119	118	148
[illegible]	[illegible]	91	101	100	100	100	103	107	106	115	115	[illegible]	92	97	94	112	110	113	109
113	115	130	116	127	124	120	136	131	113	142	145	111	121	131	122	131	137	139	135
32	40	35	40	41	43	40	43	46	42	46	48	32	36	41	34	44	48	47	47
27	24	[illegible]	28	33	30	30	32	35	35	39	38	28	33	31	33	34	33	35	31
84.4	80.2	87.3	82.0	81.6	86.7	82.4	91.6	83.7	89.9	81.6	80.0	83.6	84.0	85.5	82.7	94.4	85.1	82.2	81.8
71.7	[illegible]	70.0	85.6	78.7	80.6	83.3	75.0	81.7	74.1	81.0	79.3	73.7	74.2	74.0	77.0	85.5	80.3	81.3	80.7
[illegible]	[illegible]	94	70.0	80.5	69.8	75.0	84.4	76.1	83.3	86.7	79.2	87.5	91.7	75.6	94.1	77.3	68.8	74.5	65.9
	42.1	41.2	43.1	45.0	45.9	41.3	42.1	44.2	44.1	44.8	44.0		33.4	41.9	42.0	46.3	45.2	41.9	41.7
—	100.0	96.0	98.7	105.3	107.2	95.9	102.0	102.4	104.4	105.5	103.6	—	99.2	100.0	98.8	103.0	101.3	98.3	99.8
[illegible]	[illegible]	52.6	56.0	52.3	51.5	49.5	52.9	53.5	53.1	51.8	54.1	—	54.0	54.6	53.0	51.6	53.3	56.5	53.8
[illegible]	[illegible]	22.4	21.4	20.6	21.7	19.1	22.4	22.9	20.5	23.4	23.3		22.1	21.6	22.4	21.2	20.6	20.2	20.8

12. *Shuswap.*

I. Males																II. Females								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Donald	George Alexis	Harry Duncan	Alexander Bob	Xavier Johnny	Pierre Henry	Marcello	Philip Joseph	Antoine Célestin	George St. Paul	Nicola	Peter Bastie	John Pt'ôbat	Prospère	Patrick	Til'usmkin	Marianne Auguste	Josie Casimir	Rosie [illegible]	Augustine Enoch	Julie Célestin	Minnie Antoine	Lisette Andrew	Victoire	Mary
Sequá'pamuq (Enderby)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Enderby)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Enderby)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Clinton)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Chuk[illegible])	Sequá'pamuq (Chuk[illegible])	Sequá'pamuq (Kamloops)	Sequá'pamuq (Chuk Lakwuls)	Sequá'pamuq (Kamloops)	Sequá'pamuq (Enderby)
6	10	11	12	12	16	22	23	21	25	30	30	36	36	37	40	9	10	11	12	13	14	16	2[illegible]	6
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
1,111 [1]	1,277	1,501	1,350	1,336	1,398	1,763	1,678	1,633	1,744	1,682 [2]	1,612	1,557	1,716	1,677	1,609 [4]	1,172	1,305	[illegible]	[illegible]	1,117	1,451	1,443	1,552	1,550 [6]
884	1,003	1,045	1,077	1,121	1,207	1,438	1,382	1,330	1,327	1,383	1,356	1,473	1,103	1,367	1,311	913	1,136	1,112	1,092	1,158	1,212	1,174	1,278	[illegible]
469	539	557	503	638	687	766	755	718	756	751	720	737	769	752	705	509	694	626	612	615	677	641	697	—
1,172	1,293	1,29[illegible]	1,368	1,476	1,614	1,844	1,76[illegible]	1,784	1,837	1,627	1,721	1,761	1,818	1,701	1,713	1,160	1,362	[illegible]	1,4[illegible]	1,484	1,580	1,512	1,638	1,623
638	702	716	750	765	800	920	898	861	932	901	865	841	902	892	866	650	717	752	717	822	811	798	837	823
253	284	283	286	312	340	404	395	402	401	415	372	365	391	410	387	255	297	315	305	236	341	325	3[illegible]1	340
172	173	176	18[illegible]	180	184	192	192	193	201	187	181	183	200	191	198	177	171	179	176	179	175	184	189	181
148	161	117	163	151	161	164	156	160	160	168	162	156	151	161	166	113	140	118	112	161	150	156	136	160
99	105	101	109	105	108	121	121	123	131	133	122	119	120	123	120	99	106	109	106	118	107	110	117	120
125	127	124	128	139	131	118	144	140	152	158	145	140	150	152	161	121	126	128	129	134	134	143	140	150
42	45	48	48	46	48	54	53	54	60	60	57	56	59	56	48	41	44	46	45	44	46	43	49	53
33	31	28	34	35	36	41	38	40	42	39	40	41	43	43	41	31	30	34	32	34	33	31	37	36
86.0	87.3	83.5	83.6	83.9	82.1	85.4	81.3	83.1	79.6	89.8	89.5	85.2	77.0	84.3	83.8	80.8	81.9	82.7	80.7	81.4	85.7	84.8	82.5	88.4
79.2	82.7	83.9	85.2	76.1	80.6	81.8	84.0	82.6	86.2	84.2	84.1	91.5	80.0	82.2	77.3	81.8	84.1	85.2	82.2	88.1	79.9	76.9	90.0	80.0
78.6	68.9	58.3	70.8	72.9	75.0	75.9	71.7	74.1	70.0	65.0	70.2	73.2	81.1	76.8	86.4	75.6	68.2	73.9	71.1	77.3	71.7	72.1	75.5	67.9
41.1	42.8	42.9	43.0	45.6	45.8	44.1	45.0	44.0	43.4	44.0	43.9	44.4	41.7	44.8	43.8	43.5	52.2	45.6	45.7	42.7	45.7	44.2	44.1	—
102.8	102.6	99.7	101.3	105.4	107.6	106.0	105.1	107.6	105.6	108.7	104.9	106.3	105.7	106.6	106.4	99.7	104.0	106.2	105.1	103.1	106.8	104.3	103.7	104.7
56.0	55.7	55.1	55.6	54.7	53.3	52.0	53.5	52.8	53.0	53.6	52.7	50.7	52.4	53.1	53.7	55.6	54.7	54.5	55.7	57.1	51.8	55.0	53.0	53.1
22.2	22.5	21.8	21.2	22.3	22.7	23.2	23.5	21.7	23.0	24.7	22.7	22.0	22.7	24.4	24.0	21.8	22.7	22.8	22.8	20.6	23.0	22.4	23.0	21.9

12A. *Shuswap Half-bloods.*

I. Males					II. Females				
1	2	3	4	5	6	7	8	9	10
Nkbudaskt	André Manuel	Basil Falardeau	Alexander Leonard	Maggie Falardeau	Lizzie Ignace	Amy Manuel	Te'lsgo	Catherine Falardeau	Nellie Falardeau
F. Sequá'pamuq M. ½ Spuzzum, ½ Mulatto	F. Sequá'pamuq M. ½ Sequá'pamuq ½ White	F. ½ French, ½ Sequá'pamuq M. Sequá'pamuq	F. White M. Sequá'pamuq	F. ½ French ½ Sequá'pamuq M. Sequá'pamuq	F. English M. Sequá'pamuq	F. Sequá'pamuq M. ½ Sequá'pamuq ½ White	F. Sequá'pamuq M. ½ Spuzzum, ½ Mulatto	F. ½ French ½ Sequá'pamuq M. Sequá'pamuq	F. ½ French ½ Sequá'pamuq M. Sequá'pamuq
3	9	12	13	8 or 0	10	13	16	18	22
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
1,26[illegible]	1,215	[illegible]	1,427	1,213	1,[illegible]11	1,468	1,16[illegible]	1,588	1,58[illegible]
1,0[illegible]	950	1,105	1,137	953	1,061	1,185	1,180	1,257	1,291
538	490	530	607	622	591	655	637	710	681
1,48[illegible]	1,273	1,418	1,428	1,233	1,408	1,547	1,498	1,580	1,61[illegible]
693	656	736	768	664	727	773	769	822	810
263	266	307	305	269	307	316	346	361	370
181	176	175	184	175	175	173	179	185	181
159	11[illegible]	150	149	147	160	156	154	159	156
[illegible]	[illegible]	106	107	97	98	103	102	111	112
131	125	123	132	124	132	137	137	142	138
[illegible]	41	45	44	41	39	46	43	51	47
32	33	33	32	34	32	34	37	38	37
87.6	84.7	85.7	81.0	84.0	85.7	87.1	86.0	85.9	85.1
74.0	78.4	86.2	81.1	78.2	74.2	75.2	74.5	78.2	81.2
84.2	75.0	73.3	72.7	82.9	82.0	73.9	56.0	74.5	78.7
42.7	40.2	42.4	42.4	43.1	44.1	44.6	43.3	44.7	43.1
101.6	104.3	101.2	100.0	101.9	105.1	105.2	101.9	105.7	104.0
57.0	53.8	53.0	55.1	54.9	54.3	52.6	51.6	51.7	53.2
20.9	21.8	22.1	21.3	22.2	22.9	21.5	23.5	22.7	22.7

13. *Okanagan.* — 13A. *Half-blood Okanagan.*

13. Okanagan I. Males	13. Okanagan II. Females		13A. Half-blood Okanagan Males	
1	2	3	1	2
Allen [illegible]dward	Julienne François [illegible]	Victoire	Simon Kamloops	Edward Moreno
Okanagan	Okanagan	Okanagan	F. White M. Okanagan	F. ½ Mexican ½ Okanagan M. Okanagan
12	12	18	11	11
mm.	mm.	mm.	mm.	mm.
1,372	1,5[illegible]4	1,6[illegible]2	1,657	1,270
1,101	1,103	1,284	1,087	933
590	610	710	608	542
1,380	1,556	1,62[illegible]	1,369	1,262
7[illegible]3	71[illegible]	[illegible]	738	708
2[illegible]7	302	350	288	281
17[illegible]	174	188	177	183
15[illegible]	150	147	145	143
[illegible]	89	110	97	103
1[illegible]4	131	140	126	123
4[illegible]	41	43	41	44
32	29	33	30	34
85.8	86.2	78.2	81.9	78.1
82.5	75.6	84.6	77.0	83.7
84.4	70.7	76.7	73.2	77.3
43.7	45.2	45.8	44.1	42.7
102.2	103.4	101.7	100.7	99.4
54.3	54.8	52.9	54.3	55.8
22.0	22.4	22.6	21.2	22.1

[1] Son of Nos. 11 and 25. [2] Father of No. 1. [3] Father of half-bloods Nos. 1 and 8. [4] Mother of No. 1. [5] Son of Shuswap No. 10; brother of No. 8. [6] Daughter of Shuswap No. 16; sister of No. 1.

Kwakiutl, so far as they are represented in my measurements, belong to one type, the tables reveal considerable differences among the subdivisions of the Ntlakyā'pamuq. Besides the groups named above, I subdivided the Utā'mk·t into two groups, that of Spuzzum and that of the villages higher up Fraser River. Unfortunately, in the limited time at my disposal, I was unable to obtain measurements of the Stlaqā'yuq of Fraser River and of the Cawā'qamuq of Nicola Valley. A study of the last-named group would be of interest on account of the admixture of Tinneh blood in this region.

In the following pages the measurements and a few tables which show the principal results obtained by their means are given.

It will be seen (pp. 530 and 531) that the statures of men and women of the different tribes are nearly arranged in the same order, differences appearing only in cases where the number of observations is very small. I have given the averages of the various series, not because I consider the averages as the typical values of the tribes, but because they give a convenient index for purposes of comparison. The table shows a gradual decrease in stature as we go southward along the coast from Alaska to Fraser River. In the series for men the stature decreases from 173 cm. among the Tlingit to 169 cm. among the Haida and Tsimshian; while the Nass River tribes, who live farther inland, and who are probably mixed with Tinneh tribes of the interior, are only 167 cm. tall, the Tinneh of the interior being in their turn only 164 cm. tall. As we proceed southward, the stature decreases to 166 cm. among the Bilqula, 164 among the Kwakiutl, 162 in the Delta of Fraser River, and reaches its minimum of 158 cm. on the shores of Harrison Lake. As we go southward, the stature increases again, but its distribution becomes very irregular. The Salish tribes of Puget Sound and the Yakonan, Tinneh, and other tribes of Oregon have a stature of 165 cm. It seems that the Clallam and Nanaimo represent a taller people, but I am not quite certain of this, as some of the taller half-breeds may have been included in these series. On Columbia River the Chinook, who extend from Dalles to the coast, represent a taller type of a stature of 169 cm., which may be considered as a continuation of the tall Sahaptin type, which has a stature of 170 cm. South of the Oregonian Tinneh the stature increases slightly, reaching 168 cm. among the Klamath, and sinking again to 166 among the Hoopa. The tribes of California, who lived north of San Francisco, and who are gathered on the Round Valley Reservation, near Cape Mendocino, represent a very short type of 162 cm. only, which is also distinguished by its elongated head. When we consider the stature of the inland tribes, we may say that the stature decreases north and south from Columbia River. The Sahaptin, a people of a stature of 170 cm., represent the tallest type; northward we find the Spokane and Okanagan 168 cm. tall, the Shuswap of South Thompson River of the same stature, while those of North Thompson River measure 167 cm. only. The Chilcotin measure only 164 cm. Along Columbia River the tall stature extends to the sea. In the part of Oregon east of the Cascade Range, and in western Nevada, we find statures of 168 cm., while the Shoshone tribes of Idaho and Utah measure 166 cm. only.

I have added to these tribes the Eskimo of Alaska and those of Labrador. It will be seen that, while the latter are exceedingly short

Stature of Men of Tribes of the Pacific Coast.

Cm.		144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	164 165	166 167	168 169	170 171	172 173	174 175	176 177	178 179	180 181	182 183	184 185	186 187	188 189	Averages	Number of Cases Observers
Eskimo of Labrador		—	—	—	—	6	4	5	3	2	3	1	2	—	—	—	—	—	—	—	—	—	—	—	157·5	26 Sornberger
Eskimo of Alaska		—	—	—	—	—	—	—	1	6	4	5	5	7	4	—	2	—	—	—	—	—	—	—	165·8	34 —
Tlingit		—	—	—	—	—	—	—	—	—	—	2	—	4	—	2	3	—	1	1	2	—	—	—	173·0	15 Hendrichson, Krause, Brown
Haida		—	—	—	—	—	1	—	—	—	5	5	5	5	3	5	4	1	1	1	1	1	—	—	169·5	38 Brown
Nass River Indians		—	—	—	—	—	—	—	—	1	5	3	2	2	3	3	—	1	—	—	—	—	—	—	167·0	20 Boas
Tsimshian		—	—	—	—	—	—	—	—	—	3	5	4	2	5	2	6	1	1	—	—	—	—	—	169·3	29 Brown
Bilqula		—	—	—	—	—	1	—	3	3	1	2	4	5	2	4	1	—	—	—	—	—	—	—	166·0	26 Boas
Kwakiutl		—	—	—	—	—	—	2	8	3	6	7	4	2	4	2	2	—	—	—	—	—	—	—	164·4	40 Boas
Delta of Fraser River		—	1	—	1	—	1	1	1	7	6	3	8	1	—	—	—	—	—	—	—	—	—	—	161·8	30 Boas and Greer
Harrison Lake		2	—	1	—	—	—	1	2	—	2	2	—	—	—	1	—	—	—	—	—	—	—	—	158·0	11 Boas
Spuzzum	Ntlakyāpamuq	—	—	2	—	2	—	2	1	5	4	3	3	—	—	1	—	—	—	—	—	—	—	—	160·5	22 Boas and Greer
Utāmk't		—	—	2	—	—	1	1	1	1	1	1	1	1	2	—	—	—	—	—	—	—	—	—	161·0	12 Boas
Ntlakyāpamuq'ō'e.		—	—	—	2	1	4	2	3	3	8	5	8	3	4	1	—	—	—	—	—	—	—	—	162·7	44 Boas and Greer
Nkamtcī'nEmuQ		—	—	—	1	—	—	1	—	2	—	3	4	—	1	2	—	—	—	—	—	1	—	—	165·7	15 Boas
Shuswap, Kamloops		—	—	—	—	—	—	1	1	2	2	4	6	16	1	4	3	2	1	—	—	—	—	—	167·9	43 Boas, Greer, Watt
Northern Shuswap		—	—	—	—	2	2	—	1	3	6	6	9	5	5	6	2	2	2	—	—	—	—	—	166·8	51 Watt
Okanagan		—	—	—	—	—	—	2	—	1	4	8	12	10	13	8	4	7	—	—	—	—	—	—	168·1	69 Greer and Lawrence
Tinneh		—	—	—	1	—	1	1	1	4	2	1	2	1	1	2	—	1	—	—	—	—	—	—	163·7	18 Watt
Cowitchan and Clallam		—	—	—	—	—	—	—	—	2	—	3	1	3	2	—	1	1	1	—	1	—	—	—	169·4	18 Brown and Waughop
Puget Sd., Makah, Quinaielt		—	—	—	1	1	1	5	7	14	13	11	13	10	6	6	3	2	—	—	—	—	—	—	164·5	93 Waughop and Boas
Chinook		—	—	—	—	—	—	—	2	1	1	1	3	4	2	1	3	3	1	—	—	—	—	—	169·1	22 O'Neill and Boas
Sahaptin		—	—	—	—	—	—	1	1	—	4	11	6	11	11	8	9	6	3	—	—	—	—	—	169·7	71 Moncrieff and Strominger
Coast of Oregon		—	—	—	—	1	1	4	1	12	6	9	4	11	8	—	2	—	1	—	—	—	—	—	164·8	60 Boas and Lawrence
Klamath		—	—	—	—	—	1	1	1	1	2	5	3	4	3	3	4	1	—	1	—	—	—	—	167·9	30 Moncrieff
Hoopa		—	—	—	—	—	1	1	3	1	3	5	5	7	—	2	2	2	—	—	—	—	—	—	166·1	32 Moncrieff and Lengfeldt
Round Valley		—	—	—	1	3	2	2	1	4	6	6	—	2	1	1	1	—	—	—	—	—	—	—	161·8	30 Chesnut
Piute, Nevada		—	—	—	1	—	—	1	4	1	4	6	13	8	11	9	5	3	—	1	—	1	—	—	168·3	68 Biedenbach and Lawrence
Shoshone and Ute		—	—	—	—	1	1	5	7	13	14	16	18	15	12	6	8	1	2	—	—	1	1	—	166·1	121 Bolton and Shaw

Stature of Women of Tribes of the Pacific Coast.

Cm.	136 137	138 139	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	164 165	166 167	168 169	170 171	172 173	174 175	176 177	178 179	Averages	Number of Cases. Observers
Eskimo of Labrador	1	1	1	1	2	1	1	2	4	1	—	—	1	—	—	—	—	—	—	—	—	—	148·0	16 Sornberger
Eskimo of Alaska	—	—	1	—	1	1	—	2	3	5	5	2	4	1	—	—	1	—	—	—	—	—	155·1	26 —
Tlingit	—	—	—	—	—	—	—	2	—	1	—	1	—	—	1	—	—	—	—	—	—	—	156·0	5 Hendrichson
Haida	—	—	—	—	—	—	—	2	1	1	1	—	1	—	—	2	—	—	—	—	—	—	157·3	8 Brown
Nass River Indians	—	—	—	—	—	—	1	2	2	7	4	2	—	—	—	—	—	—	—	—	—	—	154·3	18 Boas
Tsimshian	—	—	—	—	—	—	—	—	1	3	2	6	2	3	1	—	—	—	—	—	—	—	158·4	18 Brown
Bilqula	—	—	—	—	—	—	—	—	1	2	—	2	1	—	—	—	—	—	—	—	—	—	156·8	6 Boas
Kwakiutl	—	—	—	—	—	1	5	6	5	5	5	4	3	2	—	—	—	—	—	—	—	—	153·7	36 Boas
Delta of Fraser River	—	—	—	—	2	3	2	4	4	5	2	—	—	—	—	—	—	—	—	—	—	—	151·0	22 Greer
Harrison Lake	—	—	—	2	—	—	1	1	—	3	—	1	—	—	—	—	—	—	—	—	—	—	150·9	8 Boas
Spuzzum (Ntlakyāpamuq)	—	—	—	1	1	—	1	2	1	5	3	1	—	—	—	—	—	—	—	—	—	—	152·7	15 Greer and Boas
Utā'mk·t (Ntlakyāpamuq)	—	—	—	1	—	1	1	3	3	3	1	3	1	—	—	—	—	—	—	—	—	—	153·2	17 Boas
Ntlakyāpamuq'ō'■ (Ntlakyāpamuq)	—	—	2	1	3	2	6	10	13	14	11	6	2	1	—	1	—	—	—	—	—	—	153·0	74 Greer and Boas
Nkamtcī'nemuq (Ntlakyāpamuq)	—	—	—	—	—	—	—	—	2	2	1	2	4	—	1	—	—	—	—	—	—	—	157·7	12 Boas
Shuswap, Kamloops	—	—	—	—	1	1	1	1	7	4	3	10	1	—	—	—	1	—	—	—	—	—	155·4	30 Greer and Boas
Northern Shuswap	—	—	—	—	—	3	2	3	5	4	4	6	1	—	—	—	—	—	—	—	—	—	153·9	28 Watt
Okanagan	—	—	—	—	1	—	2	2	5	7	4	4	4	4	—	1	—	1	—	—	—	—	156·5	35 Lawrence, Greer, Boas
Tinneh	—	—	—	—	—	—	—	1	1	4	—	3	1	4	—	—	1	—	—	—	—	—	158·5	15 Watt
Cowitchan and Clallam	—	—	—	—	—	—	—	1	2	—	4	1	2	—	—	—	—	—	—	—	—	—	156·4	10 Waughop and Brown
Puget Sd., Makah, Quinaielt	—	—	—	—	2	5	4	8	13	17	11	8	7	—	—	—	—	—	—	—	—	—	154·0	75 Waughop
Chinook	—	—	—	—	1	—	—	1	1	1	—	1	1	—	—	1	—	—	—	—	—	—	155·7	7 Moncrieff and Boas
Sahaptin	—	—	—	—	—	1	1	—	2	8	7	7	4	4	—	1	1	—	—	—	—	—	157·4	36 Strominger, Moncrieff, Wilgus, Boas
Coast of Oregon	—	—	1	—	—	—	3	4	6	3	2	3	—	1	1	—	2	—	—	—	—	—	154·5	26 Lawrence and Boas
Klamath	—	—	—	—	—	—	—	2	1	3	4	3	4	1	2	2	1	—	—	—	—	—	159·1	23 Moncrieff
Hoopa	—	—	—	—	—	1	—	3	1	2	5	1	1	2	1	—	—	—	—	—	—	—	155·9	17 Lengfeldt
Round Valley	—	1	1	—	1	1	4	2	7	6	3	1	—	1	—	—	2	—	—	—	—	—	152·7	30 Chesnut
Piute, Nevada	—	—	—	—	—	2	—	1	4	10	6	5	4	—	2	—	—	—	—	—	—	—	155·0	34 Biedenbach
Shoshone and Ute	—	—	—	—	—	2	2	3	5	3	4	—	—	1	—	—	—	—	—	—	—	—	152·9	20 Shaw and Bolton

the stature of those of Alaska equals that of the Bilqula, reaching 166 cm. The measurements of the Alaskan Eskimo prove clearly that they are mixed to a considerable extent with Tinneh blood.

I think the points of particular interest brought out by this statement are the gradual change of stature in British Columbia and the great irregularity of distribution in the southern regions. There are no differences of food supply or mode of life of the people which would have the effect that the stature should be lowest on Lower Fraser River, and increase in both directions along the coast, or that the same decrease should be found as we descend Fraser River. It seems that these phenomena can be explained only by a slow permeation of the tall tribes of the north and of the short tribes of Fraser River. It is curious to note that the distribution of stature shows regular changes, while all other features are distributed in quite a different manner, as will appear later on.

It is of some interest to compare the stature of men and women. When we consider the tribes contained in the preceding list, we find the following result :—

Stature of men	Average stature of men	Stature of women in per cent. of that of men
mm.	mm.	
1575–1627	1605	94·2
1637–1660	1650	94·4
1661–1681	1671	93·1
1683–1697	1692	92·7

The proportionate difference between the stature of men and women is the less the smaller the people. The same result appears from a study of the Indians of the whole of North America, as is shown in the following table :—

Stature of men	Average stature of men	Stature of women in per cent. of that of men
mm.	mm.	
1660 and less	1637	93·6
1660–1699	1684	92·9
1700 and more	1712	92·7

While for the middle group the values are almost the same as those found on the Pacific coast, the women of the short tribes of the Pacific coast seem to be taller than those of the short tribes of other regions.

Before discussing the types found on the Pacific coast any further I shall give tabulations showing the principal results of the measurements. The proportions of the body are computed in such a manner that the stature is taken at the nearest centimetre, and divided in the other measurements.

Length of Head of Men.

Mm.	174 175	176 177	178 179	180 181	182 183	184 185	186 187	188 189	190 191	192 193	194 195	196 197	198 199	200 201	202 203	204 205	206 207	Average	Number of Cases
Tribes:																			
Nass River Indians	—	—	—	—	—	—	2	2	3	2	5	3	2	1	1	3	1	195·5	25
Bilqula	1	—	1	2	4	—	—	4	3	4	4	—	—	1	—	—	—	191·3	25
Harrison Lake	1	1	1	3	2	3	2	1	—	—	1	—	—	—	—	—	—	183·0	15
Spuzzum	—	—	—	3	1	2	1	—	1	1	1	—	1	—	1	—	—	186·7	12
Utā'mk·t	—	2	—	—	2	3	1	5	3	—	2	—	—	—	—	—	—	186·7	18
NtlakyāpamuQ'ō'e	—	—	1	4	2	3	6	2	3	3	—	2	—	—	—	—	—	186·9	26
Nkamtcī'nEmuQ	—	—	1	2	—	1	7	2	3	—	2	1	1	—	1	—	—	188·9	21
Shuswap	—	—	—	1	1	—	1	—	1	3	—	—	1	2	—	—	—	191·8	10
Oregonian Tinneh	—	1	—	1	1	2	2	2	4	3	2	—	—	1	—	—	—	188·9	19

Length of Head of Women.

Mm.	166 167	168 169	170 171	172 173	174 175	176 177	178 179	180 181	182 183	184 185	186 187	188 189	190 191	192 193	194 195	196 197	Average	Number of Cases
Tribes:																		
Nass River Indians	—	—	—	—	—	—	1	3	3	3	4	2	1	3	—	1	186·2	21
Kwakiutl	—	—	—	—	—	1	—	—	—	1	2	3	—	1	—	—	186·5	8
Harrison Lake	1	—	2	—	2	3	2	—	1	—	1	—	—	—	—	—	176·0	12
Spuzzum	—	—	—	—	—	—	—	1	2	—	1	1	—	—	—	—	184·2	5
Utā'mk·t	—	1	—	1	1	3	3	2	2	3	1	2	—	—	—	—	180·1	19
NtlakyāpamuQ'ō'e	1	1	2	3	3	—	7	5	4	2	3	2	—	—	—	—	178·8	33
Nkamtcī'nEmuQ	—	—	—	1	1	1	4	1	2	1	1	1	1	—	—	—	181·0	14
Oregonian Tinneh	—	—	—	2	2	—	—	—	1	2	2	1	—	—	—	—	180·9	10

Breadth of Head of Men.

Mm.	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	164 165	166 167	168 169	170 171	172 173	174 175	Average	Number of Cases
Tribes:																	
Nass River Indians	—	—	1	—	—	3	4	5	3	4	4	1	—	—	—	161·5	25
Bilqula	—	1	1	2	1	6	4	4	—	4	—	2	—	—	—	158·7	25
Harrison Lake	—	—	—	—	2	—	—	3	2	1	2	2	—	2	1	164·5	15
Spuzzum	—	—	1	—	3	2	2	—	—	1	—	2	—	1	—	159·7	12
Utā'mk·t	—	—	2	—	2	4	2	4	1	3	—	—	—	—	—	158·3	18
NtlakyāpamuQ'ō'e	2	4	5	2	3	3	3	2	2	—	—	—	—	—	—	153·7	26 [1]
Nkamtcī'nEmuQ	—	1	6	4	1	2	3	3	1	—	—	—	—	—	—	154·6	21
Shuswap	—	—	—	—	1	2	—	3	1	1	1	1	—	—	—	160·7	10 [2]
Oregonian Tinneh	—	—	1	4	1	2	3	4	1	2	1	—	—	—	—	158·0	19

[1] 155·9 (37 cases), M. Greer.
[2] 158·6 (39 cases), M. Greer.

Breadth of Head of Women.

Mm.	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	164 165	Average	Number of Cases
Tribe:															
Nass River Indians	—	—	2	1	1	3	1	4	6	2	—	1	—	153·6	21
Kwakiutl	—	—	—	—	—	2	2	1	—	—	2	—	—	154·3	7
Harrison Lake	—	—	1	—	1	3	2	—	1	2	1	—	1	153·9	12
Spuzzum	—	—	—	1	—	—	3	1	—	—	—	—	—	151·8	5
Utā'mk·t	—	—	1	4	1	4	4	1	3	1	—	—	—	151·2	19
NtlakyāpamuQ'ō'e	2	2	3	8	8	3	6	1	—	—	—	—	—	147·7	33 [1]
Nkamtcī'nEmuQ	—	2	4	2	5	1	2	—	—	—	—	—	—	147·0	16
Shuswap	—	—	—	1	—	—	—	—	2	—	1	—	—	154·8	4 [2]
Oregonian Tinneh	—	—	—	3	2	2	—	1	1	1	—	—	—	149·1	10

[1] 152·0 (58 cases), M. Greer.
[2] 155·1 (30 cases), M. Greer.

Height of Face of Men.

Mm.	104 105	106 107	108 109	110 111	112 113	114 115	116 117	118 119	120 121	122 123	124 125	126 127	128 129	130 131	132 133	134 135	136 137	138 139	140 141	Average	Number of Cases
Tribe:																					
Nass River Indians	—	—	1	2	1	—	1	3	2	3	3	3	—	—	1	—	—	—	—	120·5	20
Bilqula	—	—	—	—	—	1	1	—	2	2	1	3	6	3	2	1	—	2	—	127·9	24
Kwakiutl	—	—	—	—	—	—	2	1	2	1	4	8	5	6	4	4	3	—	3	129·1	43
Fraser Delta	—	—	—	—	—	—	—	1	—	2	—	—	—	—	1	—	1	—	—	126·4	5
Harrison Lake	1	1	—	—	2	1	2	2	—	2	—	—	—	—	—	—	—	—	—	115·5	11
Spuzzum	—	1	—	1	—	2	1	2	3	—	—	1	—	1	1	—	—	—	—	119·7	13
Utā'mk·t	—	—	—	1	—	—	3	—	5	1	—	—	—	1	—	—	—	—	1	121·7	12
Ntlakyāpamuq'ō'e	—	—	1	1	—	1	2	6	2	2	2	1	—	—	—	—	—	—	—	119·4	18
Nkamtcī'nEmuq	—	—	—	2	—	2	1	2	1	1	2	—	2	1	—	1	—	—	—	121·6	15
Shuswap	—	—	—	—	1	—	—	1	4	1	1	—	—	1	1	—	—	—	—	123·0	10
Columbians	—	—	—	—	—	1	—	—	1	—	2	—	4	—	—	—	—	—	—	124·6	8
Oregonian Tinneh	—	—	—	—	1	2	2	—	1	2	4	—	2	2	2	—	2	—	—	125·3	20

Height of Face of Women.

Mm.	94 95	96 97	98 99	100 101	102 103	104 105	106 107	108 109	110 111	112 113	114 115	116 117	118 119	120 121	122 123	124 125	126 127	128 129	130 131	132 133	134 135	136 137	138 139	Average	Number of Cases
Tribe:																									
Nass River Indians	—	—	—	—	—	2	1	2	3	1	3	3	2	1	—	1	—	—	—	—	—	—	—	113·4	19
Bilqula	—	—	—	—	—	—	—	—	—	—	—	—	2	1	1	2	—	—	—	—	—	—	—	121·7	6
Kwakiutl	—	—	—	—	—	—	1	—	2	1	3	4	4	4	4	1	2	6	3	—	1	—	1	121·8	37
Harrison Lake	1	—	1	—	—	—	1	2	2	2	2	—	1	—	—	—	—	—	—	—	—	—	—	109·3	12
Spuzzum	—	—	—	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	113·0	3
Utā'mk·t	—	—	—	—	—	1	2	3	3	1	—	2	3	2	—	—	—	—	—	—	—	—	—	113·1	17
Ntlakyāpamuq'ō'e	—	—	1	—	1	1	1	3	6	7	2	2	3	1	1	—	—	—	—	—	—	—	—	112·5	29
Nkamtcī'nEmuq	—	—	—	—	—	—	—	1	3	2	1	2	2	1	—	—	—	—	—	—	—	—	—	114·6	12
Oregonian Tinneh	—	—	—	—	—	—	—	—	2	2	1	1	1	1	1	—	—	—	—	—	—	—	—	115·7	9

Breadth of Face of Men.

Mm.	136 137	138 139	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	160 161	162 163	164 165	166 167	Average	Number of Cases
Tribes:																		
Nass River Indians	—	—	—	2	—	—	2	2	1	2	4	3	4	1	3	1	156·5	25
Bilqula	—	—	1	—	1	1	4	4	3	2	6	1	—	—	1	—	152·4	24
Kwakiutl	—	1	1	—	6	8	6	7	9	1	4	4	1	1	—	—	150·4	49
Harrison Lake	—	—	1	2	—	3	—	1	1	1	3	2	—	1	—	—	151·5	15
Delta of Fraser River	—	—	—	—	—	—	—	1	—	—	1	—	3	1	—	1	159·9	7[1]
Puget Sound	—	—	—	—	1	—	1	—	1	—	2	2	—	—	—	—	154·0	7
Spuzzum	—	—	1	—	2	4	2	—	—	3	1	—	—	—	—	—	148·7	13
Utā'mk·t	—	1	—	2	—	1	6	4	2	2	—	—	—	—	—	—	148·7	18
Ntlakyāpamuq'ō'e	1	2	—	1	6	6	6	—	2	1	—	—	—	—	—	—	146·2	25[2]
Nkamtcī'nEmuq	—	—	1	2	4	4	5	4	—	1	—	—	—	—	—	—	147·4	21
Shuswap	—	—	1	—	2	—	2	1	2	1	—	1	—	—	—	—	149·2	10[3]
Sahaptin	—	—	—	—	3	2	—	—	1	—	1	—	1	—	1	—	151·2	9[4]
Oregonian Tinneh	1	1	2	5	—	3	1	4	3	—	—	—	—	—	—	—	146·0	20
Hoopa	—	—	1	3	1	3	1	1	1	1	—	—	—	—	—	—	146·5	12

[1] 151·0 (33 cases), M. Greer. [2] 145·1 (41 cases), M. Greer. [3] 150·3 (38 cases), M. Greer. [4] 150·3 (34 cases), Dr. Moncrieff.

Breadth of Face of Women.

Mm.	126 127	128 129	130 131	132 133	134 135	136 137	138 139	140 141	142 143	144 145	146 147	148 149	150 151	152 153	154 155	156 157	158 159	Average	Number of Cases
Tribes:																			
Nass River Indians	—	—	—	—	1	1	—	1	7	3	3	4	—	1	—	—	—	143·2	21
Bilqula	—	—	—	—	—	—	1	—	—	1	2	1	—	—	—	1	—	146·7	6
Kwakiutl	—	—	—	1	3	1	4	6	4	8	8	3	2	—	—	1	—	143·1	41
Harrison Lake	—	—	—	—	1	1	5	1	1	2	1	—	—	—	—	—	—	140·3	12
Puget Sound	—	—	—	—	—	—	—	1	2	—	1	—	—	1	—	—	—	145·0	5
Spuzzum	—	—	—	—	—	—	—	—	2	1	1	1	—	—	—	—	—	144·6	5
Utā'mk·t	—	—	—	—	3	4	2	4	1	2	3	—	—	—	—	—	—	139·9	19
Ntlakyāpamuq'ō'e	1	—	1	5	7	5	5	3	4	1	1	—	—	—	—	—	—	136·8	33[1]
Nkamtcī'nEmuq	—	—	—	1	5	2	3	3	1	1	—	—	—	—	—	—	—	137·6	16
Shuswap	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Greer (143·5)	(30)
Oregonian Tinneh	—	—	1	—	2	—	3	1	1	—	2	—	—	—	—	—	—	138·7	10

[1] 138·4 (62 cases), M. Greer.

Height of Nose of Men.

Mm.	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	Average	Number of Cases
Nass River Indians	1	3	4	2	—	5	3	1	—	—	1	—	—	—	—	—	—	—	50·8	20
Bilqula	—	—	—	—	2	—	3	—	3	2	5	2	2	2	—	2	—	2	57·7	25
Kwakiutl	—	2	—	—	2	5	2	3	4	3	10	6	2	2	1	—	1	—	55·7	43
Harrison Lake	—	3	—	2	—	—	1	—	4	—	1	—	—	—	—	—	—	—	52·8	11
Spuzzum	—	—	—	3	1	2	—	—	1	2	1	—	—	—	—	—	—	—	53·9	13
Utā'mk·t	1	1	—	1	1	1	3	1	2	—	—	1	—	—	—	1	—	—	53·2	12
NtlakyāpamuQ'ō'e	—	1	1	5	2	2	2	2	2	—	—	1	—	—	—	—	—	—	52·5	18
Nkamtcī'nEmuQ	—	3	1	1	1	3	2	1	2	1	—	—	—	—	—	—	—	—	52·2	15
Shuswap	—	1	—	—	—	—	2	2	—	2	1	—	—	2	—	—	—	—	55·6	10
Oregonian Tinneh	—	—	—	1	4	2	2	2	—	4	1	1	—	1	—	—	—	1	55·0	19

Height of Nose of Women.

Mm.	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Average	Number of Cases
Nass River Indians	—	—	1	—	—	1	—	3	2	—	5	1	2	2	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	45·2	19
Bilqula	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	—	1	—	1	1	—	—	—	—	—	—	—	—	54·8	6
Kwakiutl	—	—	—	—	—	—	—	—	1	2	2	1	4	1	1	3	1	4	3	4	—	2	2	2	—	2	—	—	—	—	—	1	51·8	36
Harrison Lake	—	—	—	—	—	—	—	1	—	1	1	—	1	1	—	1	1	—	—	1	1	—	—	1	—	—	—	—	—	—	—	—	49·4	10
Spuzzum	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	47·5	4
Utā'mk·t	—	—	—	—	—	—	—	—	—	4	3	—	2	4	—	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	47·4	29
NtlakyāpamuQ'ō'e	1	—	—	—	1	—	—	1	1	2	3	4	3	—	5	4	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	49·2	12
Nkamtcī'nEmuQ	—	—	—	—	—	—	—	—	1	—	—	—	2	2	2	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	48·4	9

Breadth of Nose of Men.

Mm.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	Average	Number of Cases
Nass River Indians	—	—	—	1	—	2	2	3	1	3	4	3	—	—	1	—	—	40·1	20
Bilqula	—	—	—	3	4	2	4	1	5	1	3	—	—	—	—	—	1	38·7	24
Kwakiutl	—	—	—	4	2	3	8	8	6	1	5	3	1	—	1	—	—	39·3	42
Delta of Fraser River	—	—	—	—	—	—	1	1	1	1	—	—	—	1	—	—	—	40·6	5
Harrison Lake	—	1	—	2	2	—	3	1	1	—	2	—	—	—	—	—	—	37·5	12
Spuzzum	—	—	—	—	1	—	2	3	4	—	1	1	1	—	—	—	—	39·8	13
Utā'mk·t	—	—	1	—	1	1	1	1	5	2	—	—	—	—	—	—	—	38·8	12
NtlakyāpamuQ'ō'e	1	1	—	1	2	1	4	3	1	1	2	—	—	—	—	—	—	37·8	17
Nkamtci'nEmuQ	—	—	—	2	3	1	4	—	2	3	—	—	—	—	—	—	—	38·0	15
Shuswap	—	—	—	—	—	—	1	1	2	3	1	2	—	—	—	—	—	40·8	10

Breadth of Nose of Women.

Mm.	30	31	32	33	34	35	36	37	38	39	40	41	42	Average	Number of Cases
Nass River Indians	—	—	—	3	—	5	—	3	4	3	—	1	—	36·6	19
Bilqula	—	—	1	2	—	—	2	—	—	1	—	—	—	34·8	6
Kwakiutl	1	3	2	3	2	11	2	5	3	4	—	—	—	35·2	36
Harrison Lake	—	1	—	—	3	2	1	1	—	1	1	—	—	35·5	10
Spuzzum	—	—	—	—	—	1	1	—	—	—	1	—	1	38·3	4
Utā'mk·t	—	—	2	2	6	1	1	3	—	—	2	—	—	35·0	17
NtlakyāpamuQ'ō'e	—	3	2	5	2	6	5	3	2	—	1	—	—	34·7	29
Nkamtcī'nEmuQ	1	—	—	—	2	1	2	1	—	2	3	—	—	36·7	12

Length-breadth Index. Total Series.

Per cent.	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	Average	Number of Cases
Nass River Indians	—	—	3	2	4	9	13	5	7	8	11	2	7	—	2	—	—	—	—	—	—	—	—	83·5	73
Bilqula	—	—	—	2	1	5	2	2	2	1	4	4	5	1	2	1	—	—	—	—	—	—	—	84·4	32
Kwakiutl, undeformed	—	—	—	—	1	1	3	4	5	—	2	1	3	1	—	—	—	—	—	—	—	—	—	83·8	21
Delta of Fraser River	—	—	—	—	—	3	—	2	4	8	4	9	6	5	3	4	2	3	1	1	—	—	—	87·0	55
Harrison Lake	—	—	—	—	—	—	—	4	—	5	1	1	4	2	3	3	4	5	1	—	1	—	1	88·7	35
Spuzzum	1	—	—	—	2	1	1	—	6	1	1	2	—	1	—	—	—	1	1	—	—	—	—	83·5	12
Utā'mk·t	1	2	—	—	3	1	2	3	12	2	7	8	4	3	5	4	3	—	—	1	—	—	—	85·3	61
NtlakyāpamuQ'ō'e	—	1	4	6	5	7	4	7	13	11	6	5	6	3	3	1	2	—	—	—	1	—	—	83·6	85
Nkamtcī'nEmuQ	—	2	2	2	5	6	3	2	6	3	7	2	—	—	1	—	—	—	1	—	—	—	—	82·5	42
Shuswap	—	—	1	—	1	2	2	3	5	3	3	1	1	1	2	—	—	—	—	—	—	—	—	83·4	25

Facial Index of Men.

Per cent.	66 67	68 69	70 71	72 73	74 75	76 77	78 79	80 81	82 83	84 85	86 87	88 89	90 91	92 93	94 95	Average	Number of Cases
Tribe:																	
Nass River Indians	3	—	—	1	3	2	4	2	2	1	2	—	—	—	—	77·0	20
Bilqula	—	—	—	—	—	1	6	4	3	8	3	3	1	—	—	83·6	29
Kwakiutl	—	—	—	—	—	1	3	2	3	6	8	5	7	2	1	86·7	38
Delta of Fraser River	—	—	1	—	—	2	—	2	1	1	—	—	—	—	—	79·2	7
Harrison Lake	—	1	1	2	3	2	—	1	2	—	—	—	—	—	—	76·2	12
Spuzzum	—	—	—	2	—	2	2	1	2	4	—	—	—	—	—	80·4	13
Utā'mk·t	—	—	—	—	—	3	2	5	—	—	1	—	—	1	—	81·5	12
Ntlakyāpamuq'ō'e	—	—	1	1	—	1	2	3	2	4	2	1	—	—	—	81·6	17
Nkamtcī'nEmuq	—	—	—	—	—	1	3	4	2	1	2	1	1	—	—	82·8	15
Shuswap	—	—	—	—	—	1	—	2	2	3	1	—	1	—	—	83·6	10
Oregonian Tinneh	—	—	—	—	—	2	2	—	4	3	2	3	—	3	—	85·1	19

Facial Index of Women.

Per cent.	66 67	68 69	70 71	72 73	74 75	76 77	78 79	80 81	82 83	84 85	86 87	88 89	90 91	92 93	94 95	96 97	Average	Number of Cases
Tribe:																		
Nass River Indians	—	—	—	2	1	4	6	2	4	—	—	—	—	—	—	—	78·6	19
Bilqula	—	—	—	—	—	1	—	1	2	—	1	1	—	—	—	—	83·0	6
Kwakiutl	—	—	—	—	—	3	3	2	6	3	8	2	3	2	—	1	84·8	33
Harrison Lake	—	—	1	—	2	2	—	3	—	—	1	—	—	—	—	—	78·4	9
Spuzzum	—	—	—	1	—	1	1	1	—	—	—	—	—	—	—	—	77·8	4
Utā'mk·t	—	—	—	—	2	3	2	4	2	2	1	1	—	—	—	—	80·9	17
Ntlakyāpamuq'ō'e	—	—	—	—	2	3	7	5	3	4	2	2	1	—	—	—	81·8	29
Nkamtcī'nEmuq	—	—	—	—	1	—	—	1	4	3	—	2	1	—	—	—	84·2	12
Oregonian Tinneh	—	—	—	—	—	—	1	3	1	4	1	—	—	—	—	—	83·3	10

Nasal Index of Men.

Per cent.	50 51	52 53	54 55	56 57	58 59	60 61	62 63	64 65	66 67	68 69	70 71	72 73	74 75	76 77	78 79	80 81	82 83	84 85	86 87	88 89	90 91	92 93	94 95	96 97	Average	Number of Cases.
Tribes:																										
Nass River Indians	—	—	—	—	—	—	—	—	—	—	2	1	3	1	5	2	2	1	2	1	—	—	—	—	79·5	20
Bilqula	—	—	—	—	2	—	3	5	2	1	5	3	2	1	—	—	—	—	—	—	—	—	—	—	72·8	24
Kwakiutl	—	—	—	—	—	1	1	4	5	8	4	4	2	3	1	2	1	2	—	—	—	—	—	—	71·6	38
Delta of Fraser River	—	—	—	—	—	—	—	1	—	—	2	1	—	—	1	—	—	—	—	—	—	—	—	—	71·7	5
Harrison Lake	—	—	—	—	—	—	1	1	—	2	3	—	2	—	1	—	1	—	—	—	—	—	—	—	72·0	11
Spuzzum	—	—	—	—	—	—	—	—	—	1	1	2	1	2	—	3	—	1	—	1	—	—	—	1	79·0	13
Utā'mk't	—	—	1	—	—	—	—	—	—	1	—	3	3	1	1	1	—	1	—	—	—	—	—	—	75·9	12
Ntlakyāpamuq'ō'e	—	—	—	—	—	—	—	3	1	3	—	2	1	2	3	1	—	1	—	—	—	—	—	—	73·3	17
Nkamtcī'nEmuQ	—	—	—	—	—	—	1	1	1	—	3	1	5	1	1	1	1	—	—	—	—	—	—	—	73·6	16
Shuswap	—	—	—	—	—	—	—	1	—	—	3	1	2	1	—	1	—	1	—	—	—	—	—	—	74·0	10

Nasal Index of Women.

Per cent.	50 51	52 53	54 55	56 57	58 59	60 61	6 6	64 65	66 67	68 69	70 71	72 73	74 75	76 77	78 79	80 81	82 83	84 85	86 87	88 89	90 91	92 93	94 95	96 97	98 99	100 101	102 103	Average	Number of Cases
Tribes:																													
Nass River Indians	—	—	—	—	1	—	—	—	—	—	—	3	1	4	—	1	1	1	1	2	1	2	—	—	—	—	1	81·8	19
Bilqula	—	—	1	—	—	1	—	—	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	64·8	6
Kwakiutl	1	—	1	—	—	4	3	2	4	2	6	2	4	2	—	—	2	—	—	—	—	—	—	—	—	—	—	68·6	33
Harrison Lake	—	1	—	—	—	—	—	—	—	1	—	5	—	1	—	1	1	—	—	—	—	—	—	—	—	—	—	72·6	10
Spuzzum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	1	—	—	—	—	—	—	—	—	—	81·7	4
Utā'mk't	—	—	—	—	—	—	—	—	—	5	1	3	1	4	—	1	—	1	—	1	—	—	—	—	—	—	—	74·7	17
Ntlakyāpamuq'ō'e	—	—	—	—	1	—	1	—	1	2	3	7	2	5	2	3	—	1	—	—	—	—	1	—	—	—	—	74 6	29
Nkamtcī'nEmuQ	—	—	1	—	—	—	—	—	1	—	—	2	—	2	2	4	1	—	—	—	—	—	—	—	—	—	—	75·9	13

Index of Length of Arm of Men.

Per cent. . { from / to	39·5 39·9	40·0 40·4	40·5 40·9	41·0 41·4	41·5 41·9	42·0 42·4	42·5 42·9	43·0 43·4	43·5 43·9	44·0 44·4	44·5 44·9	45·0 45·4	45·5 45·9	46·0 46·4	46·5 46·9	47·0 47·4	47·5 47·9	48·0 48·4	Average	Number of Cases
Tribes:																				
Nass River Indians .	—	—	—	—	—	—	1	1	—	2	2	4	2	3	2	2	—	—	45·4	19
Bilqula . . .	—	—	—	—	—	1	—	—	1	2	3	6	3	4	2	1	—	1	45·4	24
Kwakiutl .	1	—	2	—	—	—	1	3	1	8	8	7	1	3	—	—	—	—	44·3	35
Harrison Lake .	—	—	—	—	—	—	—	—	2	3	—	—	2	2	1	1	—	—	45·2	11
Spuzzum . . .	—	—	—	—	—	1	—	1	2	—	3	2	1	2	—	—	—	—	44·6	12
Utā'mk·t .	—	—	—	—	—	—	—	2	1	3	3	1	1	—	1	—	—	—	44·5	12
Ntlakyāpamuq'ō'e .	—	—	—	—	—	—	—	3	4	3	3	—	2	3	—	—	—	—	44·5	18
Nkamtcī'nEmuq .	—	—	—	—	—	—	—	1	2	1	2	6	2	1	—	—	—	—	44·9	15
Shuswap . . .	—	—	—	—	—	—	—	1	2	3	3	1	—	—	—	—	—	—	44·3	10
Oregonian Tinneh .	—	—	—	—	—	1	2	—	1	2	6	1	1	1	1	—	—	1	44·7	17

Index of Length of Arm of Women.

Per cent. . { from / to	38·0 38·4	38·5 38·9	39·0 39·4	39·5 39·9	40·0 40·4	40·5 40·9	41·0 41·4	41·5 41·9	42·0 42·4	42·5 42·9	43·0 43·4	43·5 43·9	44·0 44·4	44·5 44·9	45·0 45·4	45·5 45·9	46·0 46·4	46·5 46·9	47·0 47·4	Average	Number of Cases
Tribes:																				
Nass River Indians .	—	—	—	—	—	—	—	—	—	2	3	1	5	—	4	3	—	—	—	44·3	18
Bilqula . . .	—	—	—	—	—	—	—	—	—	—	—		—	2	—	1	—	1	—	45·2	5
Kwakiutl . .	1	1	—	—	—	—	4	5	9	1	4		1	3	—	1	1	—	—	42·5	32
Harrison Lake .	—	—	—	—	—	—	—	—	—	—	—	—	1	3	2	2	—	—	—	45·0	8
Spuzzum . . .	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	1	—	—	—	44·8	3
Utā'mk·t . . .	—	—	—	—	—	—	—	1	2	3	5	2	—	3	—	—	—	—	1	43·5	17
Ntlakyāpamuq'ō'e .	—	—	—	—	—	—	1	—	3	8	2	5	4	—	2	—	2	1	—	43·6	28
Nkamtcī'nEmuq .	—	—	—	—	—	—	—	—	1	—	—	1	3	3	1	—	—	—	—	44·2	9
Oregonian Tinneh .	—	—	—	—	—	—	—	—	1	1	3	2	3	—	1	—	1	—	—	43·8	12

Index of Height sitting of Men.

Per cent. { from / to	49·5 49·9	50·0 50·4	50·5 50·9	51·0 51·4	51·5 51·9	52·0 52·4	52·5 52·9	53·0 53·4	53·5 53·9	54·0 54·4	54·5 54·9	55·0 55·4	55·5 55·9	56·0 56·4	56·5 56·9	57·0 57·4	57·5 57·9	58·0 58·4	58·5 58·9	59·0 59·4	59·5 59·9	Average	Number of Cases
Tribe:																							
Nass River Indians	—	—	—	1	3	1	2	1	2	3	1	2	3	1	—	—	—	—	—	—	—	53·7	20
Bilqula	—	—	1	1	—	2	2	3	6	2	2	—	2	2	1	—	—	—	—	—	—	53·8	24
Kwakiutl	—	—	—	1	—	—	2	4	3	8	3	2	4	4	1	2	1	—	—	—	1	54·9	36
Harrison Lake	—	—	—	—	—	3	1	2	3	—	—	1	—	—	—	—	—	—	—	—	—	53·1	10
Spuzzum	—	—	—	2	4	—	3	—	—	1	2	—	1	—	—	—	—	—	—	—	—	52·8	13
Utā'mk·t	—	—	—	—	1	1	3	3	1	1	2	—	—	—	—	—	—	—	—	—	—	53·2	12
NtlakyāpamuQ'ō'e	1	2	1	2	2	3	2	2	1	1	—	1	—	—	—	—	—	—	—	—	—	52·1	18
Nkamtcī'nEmuQ	—	2	—	2	2	4	1	3	1	—	—	—	—	—	—	—	—	—	—	—	—	52·0	15
Shuswap	—	—	1	—	—	1	3	1	4	—	—	—	—	—	—	—	—	—	—	—	—	52·9	10
Oregonian Tinneh	—	—	—	—	—	—	—	1	2	3	3	4	2	—	—	—	—	—	1	—	—	55·1	16

Index of Height sitting of Women.

Per cent. { from / to	49·0 49·4	49·5 49·9	50·0 50·4	50·5 50·9	51·0 51·4	51·5 51·9	52·0 52·4	52·5 52·9	53·0 53·4	53·5 53·9	54·0 54·4	54·5 54·9	55·0 55·4	55·5 55·9	56·0 56·4	56·5 56·9	57·0 57·4	57·5 57·9	58·0 58·4	58·5 58·9	59·0 59·4	59·5 59·9	Average	Number of Cases
Tribe:																								
Nass River Indians	—	—	—	—	—	1	—	—	2	—	2	5	3	1	2	—	1	—	—	—	—	—	54·7	17
Bilqula	—	—	—	—	—	—	—	—	1	2	1	1	1	—	—	—	—	—	—	—	—	—	54·2	6
Kwakiutl	—	—	—	—	—	1	1	2	1	3	2	5	7	3	2	2	1	—	1	2	—	—	55·4	33
Harrison Lake	—	—	—	1	—	—	1	—	2	1	1	1	1	—	—	—	—	—	—	—	—	—	53·4	8
Spuzzum	1	—	—	—	—	2	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	51·5	4
Utā'mk·t	—	—	1	1	—	1	—	1	3	1	4	1	3	1	—	—	—	—	—	—	—	—	53·6	17
NtlakyāpamuQ'ō'e	—	—	—	2	3	3	3	6	2	6	2	—	1	—	—	—	—	—	—	—	—	—	52·7	28
Nkamtcī'nEmuQ	—	—	1	1	2	1	3	—	3	1	—	—	—	—	—	—	—	—	—	—	—	—	52·1	12
Oregonian Tinneh	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Index of Finger-reach of Men.

Per cent.	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	Average	Number of Cases
Tribes:																	
Nass River Indians	—	—	—	—	—	—	1	2	4	3	6	3	—	—	—	106·4	19
Bilqula	—	—	—	—	1	1	2	2	4	1	5	4	2	1	1	106·7	24
Kwakiutl	—	2	1	—	1	1	2	6	5	6	5	3	1	2	—	105·6	35
Harrison Lake	—	—	—	—	—	—	2	1	5	2	—	1	—	—	—	105·6	11
Spuzzum	—	—	—	—	—	2	1	2	4	1	2	1	—	—	—	105·5	13
Utā'mk·t	—	—	—	—	1	—	3	2	1	2	1	—	—	—	—	104·6	10
Ntlakyāpamuq'ō'ē	—	—	—	—	1	1	3	1	7	2	—	1	—	1	—	105·2	17
Nkamtcī'nEmuq	—	—	—	1	3	—	2	2	1	3	1	—	1	—	—	104·5	14
Shuswap	—	—	—	—	—	—	—	1	3	4	1	1	—	—	—	106·5	10
Oregonian Tinneh	—	—	—	—	3	2	4	3	2	1	1	1	—	—	—	104·1	17

Index of Finger-reach of Women.

Per cent.	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	Average	Number of Cases
Tribes:																	
Nass River Indians	—	—	—	—	—	1	2	5	2	3	1	3	1	—	—	103·2	18
Bilqula	—	—	—	—	—	—	—	—	1	2	1	1	—	1	—	105·7	6
Kwakiutl	1	—	—	3	—	2	6	8	1	6	1	2	2	1	—	102·6	35
Harrison Lake	—	—	—	—	—	—	—	2	1	1	1	2	1	—	—	104·8	8
Spuzzum	—	—	—	—	—	—	1	—	1	—	—	1	—	—	—	101·8	4
Utā'mk·t	—	—	—	1	1	1	4	5	2	—	1	—	1	—	—	102·3	16
Ntlakyāpamuq'ō'ē	—	—	1	—	2	—	7	6	5	4	—	2	—	—	1	102·7	28
Nkamtcī'nEmuq	—	—	—	—	—	—	3	4	2	—	3	—	—	—	—	103·1	12
Oregonian Tinneh	—	—	—	—	1	1	—	3	1	2	1	—	—	—	—	102·7	9

I conclude from the preceding tables that we must distinguish four types on the coast of British Columbia : the northern type, represented in our tables by the Nass River Indians ; the Kwakiutl type ; that of Harrison Lake and the Salish of the interior, as represented by the Okanagan, Flathead, and Shuswap. The Ntlakyā'pamuQ appear essentially as a mixed people.

In order to bring out the differences between these types clearly I will give the average values of the various measurements and indices side by side. I repeat, however, that these averages must not be considered as the types of the various series, which are evidently exceedingly complex, but only as indices of the general distribution.

—	Nass River Indians	Kwakiutl	Harrison Lake	Shuswap
I. Men.				
Stature, in mm.	1670	1644	1580	1679
Index of length of arm	45·4	44·3	45·2	44·3
Index of finger-reach	106·4	105·6	105·6	106·5
Index of height, sitting	53·7	54·9	53·1	52·9
Length of head, in mm.	195·5	(196)	183·0	191·8
Breadth of head „	161·5	(161)	164·5	160·7
Height of face „	120·5	129·1	115·5	123·0
Breadth of face „	156·5	150·4	151·5	149·2
Height of nose „	50·8	55·7	52·8	55·6
Breadth of nose „	40·1	39·3	37·5	40·8
Length-breadth index[1]	83·5	83·8	88·8	83·4
Facial index	77·0	86·7	76·2	83·6
Nasal index	79·5	71·6	72·0	74·0
II. Women.				
Stature, in mm.	1543	1537	1509	1554
Index of length of arm	44·3	42·5	45·0	—
Index of finger-reach	103·2	102·9	104·8	—
Index of height, sitting	54·7	55·4	53·4	—
Length of head, in mm.	186·2	186·5	176·0	—
Breadth of head „	153·6	154·3	153·9	154·8
Height of face „	113·4	121·8	109·3	—
Breadth of face „	143·2	143·1	140·3	143·5
Height of nose „	45·2	51·8	49·4	—
Breadth of nose „	36·6	35·2	35·5	—
Facial index	78·6	84·8	78·4	—
Nasal index	81·8	68·6	72·6	—

[1] Total series.

It will be noticed that the series of men and women agree very closely. The types expressed by these figures may be described as follows. The Nass River Indians are of medium stature. Their arms are relatively long, their bodies are short. The head is very large, particularly its transversal diameter. The same may be said of the face, the breadth of which may be called enormous, as it exceeds the average breadth of face of the North American Indian by 6 mm. The height of the face is moderate ; therefore its form appears decidedly low. The nose is very low as compared with the height of the face, and at the same time broad. Its elevation over the face is also very slight only. The bridge is generally concave, and very flat between the eyes. The Kwakiutl are somewhat shorter, their bodies are relatively longer, their arms and legs shorter than those of the first group. The dimensions of the head are very nearly the same, but the face shows a remarkably different type, which distinguishes it fundamentally from the faces of all the other groups. The breadth of the face exceeds only slightly the average breadth of face of the Indian, but its height is enormous. The same may be said of the nose, which is very high and relatively narrow. Its elevation is also very great. The nasal bones are strongly developed, and form a steep arch, their lower end rising high above the face. This causes a very strongly hooked nose to be found frequently among the Kwakiutl, while that type of nose is almost absent in all other parts of the Pacific coast. This feature is so strongly marked that individuals of this group may be recognised with a considerable degree of certainty by the form of the face and of the nose alone. It will be noticed that in this group the facial and the nasal indices of the women indicate that their faces are more leptoprosopic, their noses more leptorrhinic, than those of the men, while among almost all races the reverse is the case. This fact led me first to suspect that the artificial deformation which is more strongly developed among women might be the cause of the peculiar form of the face of this tribe. I have shown, however, in the preceding pages that the observations give no countenance to this theory. Besides this the Bilqula show the same features and the same relation between the two sexes, although the heads of the men are not deformed, and those of the women are deformed in a different manner. The measurements of Bilqula women can, however, claim no great weight, as they are too few in number.

The Harrison Lake type has a very short stature. The head is exceedingly short and broad, surpassing in this respect all other forms known to exist in North America. The face is not very wide, but very low, thus producing a chamæprosopic form the proportions of which resemble those of the Nass River face, while its dimensions are much smaller. In this small face we find a nose which is absolutely higher than that of the Nass River Indian with his huge face. It is, at the same time, rather narrow. The lower portion of the face appears very small, as may be seen by subtracting the height of the nose from that of the face, which gives an approximate measure of the distance from septum to chin. The values of this measurement for the four types are 69, 73, 62, and 67 mm. respectively.

The Shuswap represent a type which is found all over the interior of British Columbia, Idaho, Washington, and Oregon, so far as they are inhabited by Salishan and Sahaptin tribes. Their stature is approximately 168 cm. The head is shorter than that of the tribes of Northern British Columbia or of the Indians of the plains. The face has the average height of the Indian face, being higher than that of the Nass River Indians, but lower than that of the Kwakiutl. The nose is high and wide, and has the characteristic Indian form, which is rare in most parts of the coast. The facial and nasal indices are intermediate between those of the Kwakiutl and of the Nass River tribes.

I marked together with the measurements of the Indians certain descriptive features. I give here a tabulation of these observations, but only those taken during the journey of 1894, as I find that it is very difficult to compare descriptive features on account of the large personal equation of the observers, and even of the same observer at different times. The type which is being described exerts a deep influence upon the form of description. Thus when first visiting the Indians there is a tendency to describe the lips as thick because they are compared with those of the whites, while later on they are called moderate because Indian lips are compared among themselves. Descriptive features are, therefore, of no great value, owing to the inaccuracy of the terms involved. Still, some striking differences will be noticed in the following tabulations of the descriptive features of men from 20 to 59 years of age :—

—	Bridge of Nose			Form of Nose			Point of Nose			
	High	Medium	Low	Concave	Straight	Convex	Long	Short	Thin	Thick
Nass River Indians . . .	7	10	2	4	13	3	12	5	8	9
Kwakiutl	21	5	—	1	19	11	21	8	16	13
Utā'mk·t	7	3	2	1	7	3	5	8	3	8
NtlakyāpamuQ'ō'e . . .	13	3	—	1	8	6	6	8	5	9
Nkamtcī'nEmuQ . . .	13	2	—	2	8	4	7	8	6	9

—	Ear			Lobe of Ear					
	Large	Moderate	Small	Large	Small	Attached	Detached	Round	Triangular
Nass River Indians	12	6	2	14	6	13	6	15	5
Kwakiutl . .	11	14	3	17	12	9	20	26	3
Utā'mk·t . .	4	8	—	10	2	6	6	10	2
NtlakyāpamuQ'ō'e	5	11	—	9	7	9	7	14	2
Nkamtcī'nEmuQ .	4	8	3	7	6	6	7	8	5

This tabulation makes particularly clear the difference in the form of nose found among the various tribes.

I recorded the colour of the skin according to Radde's standard colours, and selected the forehead for my comparisons. I recorded the following tints among the various tribes :—

	32						33						
	l	m	n	o	p	q	l	m	n	o	p	q	r
Nass River Indians	1	—	—	—	—	1	2	1	—	3	1	—	1
Kwakiutl	—	—	—	—	1	—	2	—	2	7	8	7	2
Utā'mk·t							—	1	1	1	1	2	—
NtlakyāpamuQ'ō'e							—	3	2	6	2	—	2
Nkamtcī'nEmuQ							—	—	2	1	—	—	—

It appears from these data that the Kwakiutl are the lightest among the people of the North Pacific coast, while the Nass River and Thompson Indians are considerably darker.

It is necessary to consider the cephalic index of the various tribes a little more closely, because it seems that among the tribes of Fraser River children are much more brachycephalic than adults. Investigations carried on by means of extensive material do not show any such differences, and it is likely that more extended investigations would cause the apparent difference to disappear; but it is also possible that in this region we may find the length of head to increase more rapidly than the breadth of head. Among the Eastern Indians, and in different parts of Europe, we find a slight decrease of the cephalic index with increasing age, but in no case does the difference exceed 1 per cent. We find also that the heads of women are somewhat shorter than those of men. The following tabulation shows that among the northern tribes the same relations prevail, but that among the Ntlakyā'pamuQ the heads of adults appear much more elongated than those of children.

Average Cephalic Index.

—	Nass River Indians	Bilqula	Kwakiutl	Harrison Lake	Spuzzum	Utā'mk·t	NtlakyapamuQ'ō'e	Nkamtcī'nEmuQ	Oregonian Tinneh
Boys .	84·0(17)	83·6 (8)	85·5(6)	90·8 (3)	83·5 (1)	86·3(13)	86·9(12)	89·5 (1)	84·0(17)
Girls .	83·5(11)	—	82·5(5)	87·1 (5)	—	88·5(12)	84·7(14)	87·8 (3)	84·4(10)
Men .	82·7(24)	84·7(24)	85·5(2)	89·8(15)	84·9(12)	84·9(17)	82·6(26)	82·0(21)	84·0(20)
Women.	82·9(20)	—	82·9(7)	87·5(12)	82·5 (5)	83·1(19)	82·8(33)	81·7(17)	83·6(10)
Children	83·8(28)	—	84·1(11)	88·5 (8)	83·5 (1)	87·4(25)	85·8(26)	88·2(4)	84·2(27)
Adults .	82·8(44)	84·7(24)	83·5 (9)	88·8(27)	84·2(17)	84·0(36)	82·7(59)	81·9(38)	83·9(30)
Total .	83·5(73)	84·4(32)	83·8(21)	88·7(35)	84·1(18)	85·3(61)	83·6(85)	82·5(42)	84·0(57)

It appears from this comparison that even if the greater brachycephalism of the children on Fraser River should be the effect of a peculiar law of growth, the general relations of the cephalic indices of adults would remain unchanged, so that the preceding considerations remain unaltered when the total series or the adults alone are considered.

It is necessary to treat two groups of tribes a little more fully, namely, the Bilqula and the Ntlakyā'pamuQ. The tables show clearly that the Bilqula are closely related to the Kwakiutl type, with which they have the high face and nose in common. The differences between the divisions of the Ntlakyā'pamuQ have been discussed above. It remains to point out the probable cause of these differences. It is evident that the lower divisions, particularly those of Spuzzum and the Utā'mk·t, are more alike to the Harrison Lake type than the divisions farther up the river. It is also evident that the Nkamtcī'nEmuQ resemble the Shuswap more than any other division of the Ntlakyā'pamuQ.

A detailed comparison is given on the following table, which also includes the Oregonian Tinneh.

It will be seen that, on the whole, an approach between the forms of Harrison Lake and that of the Shuswap is found. But the Ntlakyāpamuq'ō'e occupy, in many respects, an exceptional position. Their heads are narrow, their faces are lower and narrower than those of their neighbours. They are narrower than those of any other Indians, with the exception of the Hoopa and Oregonian Tinneh, while the Shuswaps have a face as broad as the average Indian face. These differences between the absolute measurements of the face are also expressed in the indices. The

Averages of Measurements.—Men.

Tribe	Stature	Length of Head	Breadth of Head	Height of Face	Breadth of Face	Height of Nose	Length-breadth Index	Facial Index	Nasal Index
Harrison Lake	1580(11)	183·0(15)	164·5(15)	115·5(11)	151·5(15)	52·8(11)	88·8(35)	76·2(12)	72·0(11)
Spuzzum	1605(22)	186·7(12)	159·7(12)	119·7(13)	148·7(13)	53·9(13)	83·5(12)	80·4(13)	79·0(13)
Utā'mk·t	1610(12)	186·7(18)	158·3(18)	121·7(12)	148·7(18)	53·2(12)	85·3(61)	81·5(12)	75·9(12)
NtlakyāpamuQ'ō'e	1627(44)	186·9(26)	153·7(26)	119·4(18)	146·2(25)	52·5(18)	83·6(85)	81·6(17)	73·3(17)
Nkamtcī'nEmuQ	1657(15)	188·9(21)	154·6(21)	121·6(15)	147·4(21)	52·2(15)	82·5(42)	82·8(15)	73·6(16)
Shuswap	1679(43)	191·8(10)	160·7(10)	123·0(10)	149·2(10)	55·6(10)	83·4(25)	83·6(10)	74·0(10)
Oregonian Tinneh	1648(60)	188·9(19)	158·0(19)	125·3(20)	146·0(20)	55·0(19)	—	85·1(19)	—

Averages of Measurements.—Women.

Tribe	Stature	Length of Head	Breadth of Head	Height of Face	Breadth of Face	Height of Nose	Length-breadth Index	Facial Index	Nasal Index
Harrison Lake	1509 (8)	176·0(12)	153·9(12)	109·3(12)	140·3(12)	49·4(10)	87·5(12)	78·4 (9)	72·6(10)
Spuzzum	1527(15)	184·2 (5)	151·8 (5)	113·0 (3)	144·6 (5)	47·5 (4)	82·5 (5)	77·8 (4)	81·7 (4)
Utā'mk·t	1532(17)	180·1(19)	151·2(19)	113·1(17)	139·9(19)	47·4(29)	83·1(19)	80·9(17)	74·7(17)
NtlakyāpamuQ'ō'e	1530(74)	178·8(33)	147·7(33)	112·5(29)	136·8(33)	49·2(12)	82·8(33)	81·8(29)	74·6(29)
Nkamtcī'nEmuQ	1577(12)	181·0(14)	147·0(16)	114·6(12)	137·6(16)	48·4 (9)	81·7(17)	84·2(12)	75·9(13)
Shuswap	1554(30)	—	154·8 (4)	—	143·5(30)	—	—	—	—
Oregonian Tinneh	1545(26)	180·9(10)	149·1(10)	115·7 (9)	138·7(10)	—	83·6(10)	83·3(10)	—

cephalic index decreases rapidly as we go up Fraser River, but it is higher among the Shuswap than among the Nkamtcī'nEmuQ. The facial index increases quite regularly from Harrison Lake to the Shuswap, but we must remember that the face of the NtlakyāpamuQ'ō'e is much smaller than that of the Shuswap and that of the lower divisions of the Ntlakyā'-pamuQ. The nasal index is so variable that we cannot draw any conclusions from its average values.

It seems, therefore, that there is a disturbing element among the NtlakyāpamuQ'ō'e which conceals among them the gradual approach of forms between the Harrison Lake type and that of the Shuswap. This fact does not seem surprising, as it is likely that mixture has taken place along Fraser River. The low values of the breadth of face remind us of the Tinneh tribes of Oregon and California, and I do not consider it unlikely that we may find here the effects of an admixture of Tinneh blood.

However the peculiarities of the NtlakyāpamuQ'ō'e may be explained, the fact remains that the Ntlakyā'pamuQ, who represent a people speaking one language, are physically by no means homogeneous. The upper and lower divisions indicate clearly the effect of mixture with the neighbouring tribes; while the central group, 'the real Ntlakyā'pamuQ,' present peculiarities of their own, which may be the old characteristics of the Ntlakyā'pamuQ, or which may be due to admixture of Tinneh blood. The gradual change of type along Fraser River proves clearly that these tribes must have occupied these regions for very long times, and that the population has been very stable. The differences in type between the divisions of this people offer an excellent example of the fact that linguistic and anatomical classifications do not follow the same lines; that people who are the same in type, and must therefore be related in blood, may speak different languages; and that people who differ in type may speak the same language.

It remains to give a review of the number of children of women of the tribes which I investigated. The data obtained by means of this inquiry allow us to understand the causes of the diminution in numbers among these Indians, and suggest at the same time a possible remedy for this sad fact. I give here the number of living and deceased children of all the women whom I measured, arranged according to ages.

When we direct our attention to the average number of children of women of more than forty years of age, we find the following result:—

Nass River Indians	4·8	children	(6 cases)
Kwakiutl	3·5	„	(20 „)
Utā'mk·t	5·3	„	(11 „)
NtlakyāpamuQ'ō'e	5·8	„	(13 „)
Nkamtcī'nEmuQ	5·8	„	(10 „)

Although the number of observations is small, the general result is undoubtedly correct, and agrees with the relative number of children in the villages of the various groups, the number being very small among the Kwakiutl, and much larger among the other tribes. The number of children among the Ntlakyā'pamuQ equals that found among the tribes of other parts of North America, while that of the Kwakiutl is much smaller.

The cause of the diminution of the tribes becomes clearest when we consider that group of mothers who may just begin to have adult children, that is, between the ages of thirty-five and forty-five years. At

	Ages of Mother																															
	20–24				25–29				30–34				35–39				40–44				45–49				50–59				60 and more			
	Living		Deceased		Living		Deceased		Living		Deceased		Living		Deceased		Living		Deceased		Living		Deceased		Living		Deceased		Living		Deceased	
	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters	Sons	Daughters
Nass River Indians.	— — 1 —	1 2 — —	1 1 — —	— — — —	— 2 — 1	— 2 — 3	1 1 — —	— — 3 1	— 1 1	— — 1	1 — 1	1 — —	1 2	1 1	— —	— 3	—	—	1	—	2	2	2	1	— 1	— —	— 4	— 5	— 3	1 —	1 3	— 3
Kwakiutl.	— 2 — 1	— — — —	— 2 1 1	— — — 2	— 3 —	— 1 —	2 — 2	— — 2	— — —	1 — —	— 1 —	— 1 1	— — — — 1 — —	3 — — — 1 — —	1 — — — 2 2 1	3 — — 1 1 1 —	1 — 1 — — — —	— 1 — — — — —	— — 4 2 — 1 —	— — — 1 — 2 —	— —	— —	— —	— 1	— — — —	— — 1 1	2 — — 3	8 1 1 4	— — — — — — —	— — — — — 1 1	1 3 3 3 2 1 3	3 — 1 7 1 2 2
Utā'mk·t.	1 — —	— 2 —	2 1 —	— 1 —	— 1 1	— 1 —	— 1 5	— 1 1	— — 3	— — 1 —	— 2 1 3	— — 1 3	— 4 2	— 5 3	— — 2	— — 4	4 — 4 1 1	2 — 3 2 —	4 — — — —	2 — 1 1 3					— — 2	1 — 1	3 2 1	2 5 —	— — —	— 1 1	2 3 —	3 2 1
Ntlakyāpamuq'ō'e.					2 —	1 1	2 1	3 —	— 1 1 — 2	2 2 — — 2	1 2 1 — 2	3 1 4 — 2	1 2 — — —	2 — — — 1	2 — — — —	4 4 — 1 —	3 1 1	2 — 1	1 2 1	1 3 1	—	—	—	—	2 1 — — — —	1 3 1 — — 1	8 (1 | 2) 10 (2, 1, 1 | —, 2, 1)		— — —	2 — 2	2 2 9 (sons and daughters)	3 2
Nkamtcī'nEmuq.					—	—	—	—	1	—	4	1	2 —	1 —	2 3	2 1	—	—	—	1	—	—	—	—	— 3 — —	— — — 1	7 5 1 2	5 2 1 1	— 1 2 1	— — — —	6 — 5 1	2 3 4 4

these ages they will have children who are not yet mature, but a portion of these children will be adults. If the population were to remain stable, the number of children would have to be considerably more than twice that of the mothers. The actual distribution is shown by the following figures :—

Nass River Indians	3 mothers of 35–45 years of age have	5	living	4	dead children.
Kwakiutl	14 „ „	8	„	22	„
Utā'mk·t	8 „ „	31	„	17	„
Ntlakyāpamuq'ō'e	8 „ „	14	„	20	„
Nkamtcī'nEmuq	3 „ „	3	„	9	„

This table shows how exceedingly unfavourable the conditions are among the Kwakiutl, as fourteen mothers have produced considerably less than eight mature children. The figures prove also that a very slight improvement of the sanitary conditions among the Ntlakyā'pamuq would produce an increase of the population.

The cause of the extremely unfavourable conditions among the Kwakiutl becomes particularly clear when the mothers are grouped in decades. When this is done we find the following result: —

Age of mother	20–30	30–40	40–50	50–60	60 and more.
Average number of children	2·7	2·1	1·6	5·2	4·9

That is to say, the maximum sterility is found among women who are now from forty to fifty years old, that is, who became mature about twenty-five or thirty years ago. This agrees closely with the time when the Kwakiutl sent their women most extensively to Victoria for purposes of prostitution. During the last decade a number of influential men among the tribe have set their influence against this practice, and we see at the same time a rapid increase in the number of children. The young women who have now an average number of 2·7 children may hope to regain the number of children which their grandmothers had. But the only hope of preserving the life of the tribe lies in the most rigid suppression of these visits of women to Victoria, which are still continued to a considerable extent, and in an effort to stamp out the diseases which have been caused by these visits.

II. The Tinneh Tribe of Nicola Valley.

In his Notes on the Shuswap People of British Columbia[1] Dr. G. M. Dawson first called attention to a Tinneh tribe which used to inhabit the Nicola Valley, but which has become extinct. Some notes on the history of this tribe were given by Dr. Dawson according to information obtained from Mr. J. W. McKay, formerly Indian Agent at Kamloops, who has an extensive knowledge of the Indians of the interior. As parts of this information conflicted with reports which I had received, and as it seemed desirable to gather as much information as possible on this tribe, I resolved to visit them in the course of my investigations. Owing to pressure of time I had to give up the intended journey, and requested Mr. James Teit, who is thoroughly familiar with the Ntlakyā'pamuq, to try to collect as much information as possible on the tribe. He visited Nicola Valley early in March 1895, and reports the results of his work as follows :—

[1] *Trans. Royal Soc. Canada*, vol. ix. 1891, sect. ii. p. 23.

'I saw the three old men who are said to know the old Stûwī'Hamuq language, which was formerly spoken in Nicola Valley, and found that they only remembered a few words of what they had heard from their fathers. One of them could only give me five or six words, another one twelve, and another one twenty. As many of these words were the same, I only obtained twenty distinct words and three phrases. I also learned two place-names used by them which I think are probably Tinneh. A few of the words which I obtained are not on the lists of Dr. Dawson and Mr. McKay. One Indian, who also knows some words of the language, is living at present in Similkameen ; therefore I was unable to see him. It is unfortunate that the work of collecting the remains of the language was not undertaken a few years sooner. An old woman who was half Stûwī'Hamuq died in Nicola only five years ago. She was the last person who could talk the language properly. The three Indians whom I saw are only one quarter Stûwī'Hamuq blood ; each of them is old and white-haired, and I should judge over seventy years of age. One of them said he remembered that when he was a boy his grandfather (who was then a very old man and hardly able to walk) pointed out to him the spot on the Nicola a little below the lake where he (the old man) was born, and also told him that his people had always inhabited that region. This old man must have been born in Nicola at least 120 years ago, and it seems that he had no knowledge of the origin of his tribe.

'Another old man whom I saw was taken when a lad, by his father, all over the boundaries of the tribal territory in order to impress upon him the different landmarks which constituted at that time the tribal boundaries. One of the old men named his ancestors for four generations back, saying that at that time the whole tribe lived in three camps or subterranean lodges, and that there were not very many people in each (probably from forty to fifty souls), and that they all wintered along Nicola River below the lake, and in close proximity to each other. They also had two fortified houses in which they took refuge when threatened by war parties of other tribes. The man mentioned war parties of Okanagan, Ntlakyā'pamuq, and Shuswap, who attacked their fortifications unsuccessfully. These events happened three or four generations before his time.

'Three generations ago the tribe had some admixture of Okanagan and Ntlakyā'pamuq blood. Some of them had wives from among their tribes, and the latter took wives from among them. They claim that their tribe never went on war expeditions into the territories of other tribes, and they say, with pride, that their country is the only one in this region where the white men's blood has never been shed. They have a tradition that at one time their tribe was numerous and that their southern boundary extended to Keremeous, on the Lower Similkameen River. They have no tradition regarding a foreign origin, and were quite indignant when I mentioned to them Mr. McKay's theory of their being descended from a war party of Chilcotin. They said that when young they had heard the old people of the tribe telling mythological stories, but these were just the same as those current among the Okanagan and Ntlakyā'pamuq. At my request they told me some of these stories which had been told to them by their grandfathers, and I recognised them as identical with those which I had heard at Spence's Bridge, and which are current in slightly different versions among the interior Salish. I questioned them extensively regarding the customs of their ancestors, and found that these corresponded exactly with those of the Ntlakyā'pamuq. Their weapons were also exactly the same. Their personal names, so far back as they can trace them, are also Ntlakyā'pamuq. The oldest personal name that they could give me was that of a man of note among them called Tsûqkokwa's. This is the only name that I do not recognise as Ntlakyā'pamuq. They said that the pure Stûwī'hamuq whom they had seen were of about the same height as the Ntlakyā'pamuq and Okanagan, but generally heavier in build. They were also of the same complexion. Their features were slightly different, but they could not explain wherein the difference consisted. They told me the names by which the tribe was known among themselves, and also by neighbouring tribes. These names have all the Salish suffix *-muq*, meaning *people.* These names are Sei'lEqamuq (said to mean people of the high country); Smîlê'kamuq and Stûwī'Hamuq. The last is the name by which they are principally known to the Ntlakyā'pamuq, who have from time immemorial called the upper Nicola country Stûwi'h. The Indians at Spence's Bridge say that this is probably one of the many forms of their word meaning "creek," such as Cawā'uq, Tcawa'q, Tcûwa'uq, Stcwauq. Sei'lEqamuq is decidedly a Ntlakyā'pamuq word. Smîlê'kamuq is probably connected with the place-name Smîlêkami'n or Smîlêkami'nûq, of which Similkameen is a corruption. They say that about sixty years ago the winter habitations of the Ntlakyā'pamuq extended up the Nicola River only some seventeen miles. The country above this point was recognised as belonging to the Stûwī'Hamuq. The Ntlakyā'pamuq called their division which lived along the Lower Nicola River, Tcawa'Qamuq, but the Stûwī'Hamuq called them Nkamtcī'nEmuq, and looked upon them as a part of the division extending from Thompson Siding to Ashcroft. The Tcawa'Qamuq, or Cawa'Qamuq, used in former days only to go into the Stûwi'H country in the summer and fall of the year to hunt. (The reason that the Cawa'Qamuq at that time inhabited principally the lower part of Nicola River was no doubt on account of the superior fishing facilities.) When the number of horses of the Cawa'Qamuq and Nkamtcī'nEmuq began to increase, many of these people moved up to the Stûwi'H country on account of its good grazing, and settled there about fifteen years before the advent of the white miners in 1858. After the country was partly settled by the whites more Cawa'Qamuq and Nkamtcī'nEmuq, many Uta'mk·t, and some Ntlakyāpamuq'ō'e and Okanagan settled in the Stûwi'H country, being attracted by its farming facilities. Shortly before the arrival of the whites the Okanagan commenced to make permanent settlements in the neighbourhood of Douglas Lake on account of the good grazing in that region. The Nicola Tinneh, who were already mixed with these tribes, never offered any opposition to their settlement. At the time of the advent of the whites (1858) the recognised chief of the Nicola country was NEwisîskîn, a Cawa'Qamuq, born within seven miles of Spence's Bridge. The Ntlakyā'pamuq soon became the prevailing language of that district. It seems that at least for several generations back the Stûwi'Hamuq simply acted on the defensive. The Ntlakyā'pamuq and Okanagan made what use they liked of the Stûwi'H country, hunting in it and passing through it when they desired. The Okanagan always went by that route when going to trade with the Nkamtcī'nEmuq. Parties of Shuswap, Okanagan, and Ntlakyā'pamuq on war expeditions against each other passed through the Stûwi'H country unmolested.

'One of the old men whom I saw, named Tcuiê'ska or Sê'sûluskîn, is the first person of the Ntlakyā'pamuQ whom I have seen tattooed on the body. He is one quarter Stûwi'HamuQ, one quarter Okanagan, and half Nkamtcī'nEmuQ. He said that formerly the Stûwi'HamuQ were occasionally tattooed on the body, as were also some of the Nkamtcī'nEmuQ.'

So far Mr. Teit's report. It may be mentioned in connection with these facts that the Ntlakyā'pamuQ, near the mouth of Nicola Valley, are the only people who use round lodges in summer, not square lodges, such as I described in my report on the Shuswap. This custom may be due to contact with the Tinneh tribe, or to that of the Okanagan, who are said to use round lodges.

From what we know about Indian life, Mr. McKay's theory that the Stûwi'HamuQ are descendants of a Chilcotin war party, which was hemmed in by the Ntlakyā'pamuQ, seems very unlikely, and Mr. Teit's data prove beyond a doubt that the people have lived in the Similkameen and Nicola regions for a long time. I do not doubt that they must be considered the most northern of the isolated bands of Tinneh origin which are found all along the Pacific coast.

The following is a list of all the words belonging to the language which have been collected. The names of the collectors are indicated by initials, M. standing for Mr. J. W. McKay, D. for Dr. George M. Dawson, and T. for Mr. James Teit. Mr. Teit adopted the same system of spelling that I use; where more words than one are given under his name they were obtained from different individuals.

1. *T-haeh*, M., man.
2. *Tet'-hutz*, D., man.
   Thatc, T., man.
3. *Nootl*, D., man.
4. *Tsik-hi*, M.; *tsē-a-kai'*, D.; *tsekHe'*, T., woman.
5. *Sass*, M.; *sus*, D.; *sas*, T., bear (D., grizzly bear).
6. *Si-si-aney*, M., ram of mountain sheep or big horn.
   Sis-ya-nē', D., big deer of old; either wapiti or cariboo.
   Sisiē'ni, T., ewe of mountain sheep.
   SEsia'ni, T., elk.
   (*ēstahī'tz*, T., elk, probably a corruption of *īsteha'tz*, elk in Ntlakyā'pamuQ. J. Teit).
7. *T-pae* or *ti-pae*, M.; *tpi*, T., ewe of mountain sheep or big horn.
   Ti-pī, D., mountain sheep.
8. *Tit-pîn*, T., ram of mountain sheep.
9. *Sa-pie*, M., trout; *si-pai'*, D.; *sipai'i*, T., lake trout.
10. *Hûlhûltu'tāi*, T., a small fish called *hûlu'liah* by the Ntlakyā'pamuQ.
11. *Taki'nktcîn*, T., a small fish called *eyi'nik* by the Ntlakyā'pamuQ.
12. *Zûlke'ke*, T., ground hog.
13. *Tsho*, T., buck of deer.
14. *Tlohst-ho*, M., snake; *klos-ho'*, D.; *stlosHo'*, T., rattlesnake.
15. *Tin-ih*, M.; *ti'nEH*, *tî'nuq*, T., bear-berry (Arctostaphylos).
16. *Teqo'ztz*, T., soap-berry.
17. *Notl-ta-hat'-se*, D.; *notlqa'tzi*, T.; *qtlona'zi*, T., wild currant.
18. *Ta-ta-ney*, M.; *tēt-ta-ā-nē'*, D.; *ta-a'ni*, T., knife.
19. *Sa-te-tsa-ē*, M.; *sötitsai'i*, T., spoon made of mountain-sheep horn.
    Sit-ē-tshī-i', D., spoon.
20. *Ska-kil-ih-kane*, M., rush mat.
21. *Ke*, T., bow and arrow.
22. *Naltsi'tse*, T., arrow-head.
23. *Tlutl*, *tlotl*, T., packing line.
24. *Sa-pe*, M., one.
25. *Tun-ih*, M., two.
26. *Tlohl*, M., three.
27. *Na-hla-li-a*, M., four.

28. *E-na-hlē*, M., five.
29. *Hite-na-ke*, M., six.
30. *Ne-shote*, M., seven.
31. *K-pae*, M., eight.
32. *Sas*, M., nine.
33. *Ti-li-tsa-in*, M., give me the spoon, or bring me the spoon.
34. *N-shote*, M., give it to me.
 Etl-tcot, T., I may give you.
35. *Pin-a-lē-ēl-ī-ītz*, D., look out! or take care.
36. *A'we qe*, T., come here, child!
37. *Apîn tleqi i en qäin*, T., exact meaning unknown, but used like the swearing of the whites.
38. TastHezu'li, a place-name.
39. Tîzzî'la, a place-name.

These words show that the dialect was much more closely related to the Tinneh languages of British Columbia than to those farther south, although it would seem to have differed from the former also considerably. A comparison of vocabularies, which shows the relationships of these dialects, will be found in the linguistic part of this report.

III. The Tinneh Tribe of the Portland Inlet, the Ts'ets'ā'ut.

On my second journey to British Columbia I made an effort to find members of a tribe that was reported as living on Portland Inlet, and as being slaves of 'Chief Mountain,' the chief of a Nîsk·a' clan. I received reports of this tribe from Mr. Duncan, and some additional data were learned from the Tsimshian. On my last trip I visited the village Kinkolith, at the mouth of Nass River, whither the tribe was said to resort at certain seasons of the year. There I found a boy named Jonathan and one young man named Timothy; later on, after a prolonged search, I found an elderly man, Levi. From these three men the following information was obtained. Levi was the only one who spoke the language well, while the two young men used almost exclusively the Nîsk·a' in their conversations. All the ethnological and historical data were given by Levi. The language proved, as I anticipated, to be a Tinneh dialect. The tribe is called by the Nîsk·a' and by the Tsimshian, Ts'Ets'ā'ut—those of the interior. By this name are designated all the Tinneh tribes of the interior. It does not refer to any one tribe exclusively, and corresponds to the Tlingit name Gunana'. The number of members of the tribe is reduced at present to about twelve, and only two of these continue to speak their own language correctly. The native name of the tribe is forgotten, and we must therefore continue to designate them as Ts'Ets'ā'ut. According to the testimony of the Nîsk·a' and of the Ts'Ets'ā'ut, the latter form a tribe different from the Laq'uyî'p (= on the prairie), who have their principal villages on the head waters of the Stikeen River. They are called Naqkyina (on the other side) by the Ts'Ets'ā'ut. Their town is called Gunaqä'. Levi named three closely related tribes whose languages are different though mutually intelligible: the Tahltan (Tā'tltan), of Stikeen and Iskoot Rivers; the Laq'uyî'p, or Naqkyina, of the head waters of the Stikeen; and the Ts'Ets'ā'ut. The home of the last-named tribe extended from a little north of Tcū'naq (Chunah) River, in the extreme north-eastern corner of Behm Channel, eastward to Observatory Inlet, northward to the watershed of Iskoot River. About sixty years ago this tribe numbered about five hundred souls, but they were exterminated by continued attacks of the Sā'nak·oan, the Tlingit tribe of Boca de Quadra and of the Laq'uyî'p. The present generation confine their wanderings to the surroundings of Portland Inlet, north of Port Ramsden. At my request Levi drew a map of this region, which is here reproduced. It will be seen that all the rivers of the inlet have Tinneh names. Levi gave me also the Tinneh names of the rivers emptying into Behm Channel and of several places in Observatory Inlet.

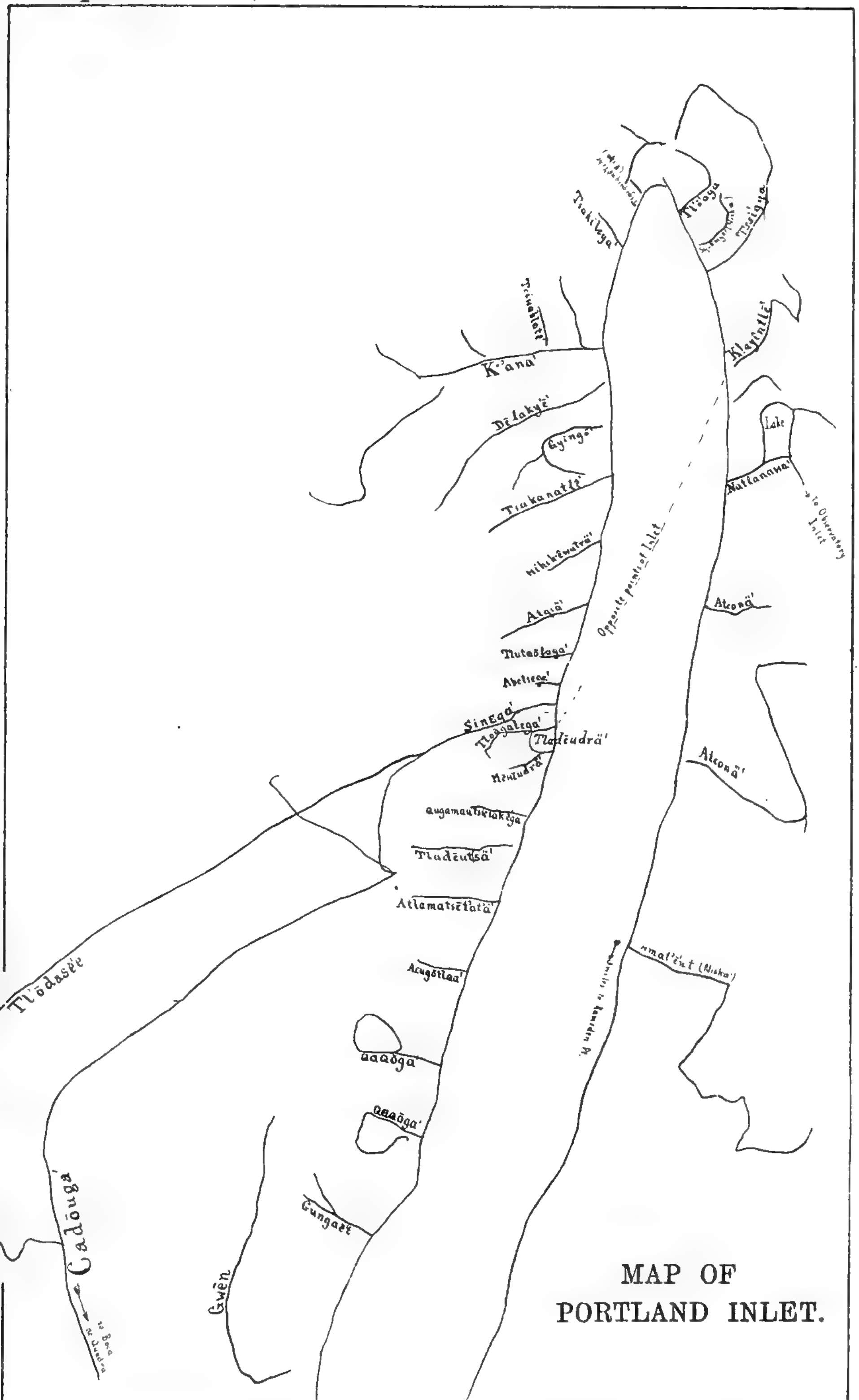
Geographical Names in the T's'ᴇts'ā'ut Territory (see map).

Ky'ētsō'ga ; Observatory Inlet.
Ky'ētsō'ga ; Hastings Arm. Nîsk·a' : Kcuwa'n.
Māātrēga ; Alice Arm.
K'aqanê' ; Larcom Island.
Atconä' (1); Nîsk·a': Gunskyē'ik.
Atconä' (2) ; „ Anukcpē'tk.
Natlanaнa' (=canoe) ; Nîsk·a' : Kcä'u.
K!ayîntlē'; Nîsk·a' : нmâ'ôtlk.
Tssi'gya ; Nîsk·a' : Guncī'ên.
Tl'ō'aga ; Nîsk·a' : нiō'dzi.
Tsakilega' ; Nîsk·a' : Gunaqnē't.
K·'anā' ; Nîsk·a' : Sk·amgō'ns.
Dēlaky'ē' (=dog salmon) ; Nîsk·a' : Laqнk·alā'n.
Tsakanatlê' ; Nîsk·a' : Gyidziks'ā's.
нihik·êwuträ' ; Nîsk·a' : Angulikcō'otk.
Atqiä' ; Nîsk·a' : Angutlqä'k·sk.
Tlūtaōlaga' (=salmon); Nîsk·a' : Gyînmē'lîk·st.
Abᴇtsēga' (=Mountain Goat Creek) ; Nîsk·a': Anlē'k·s.
Sinᴇga' ; Nîsk·a' : нmā'enik·tl.
Tloāgalega' ; Nîsk·a' : Gyîlʟ·ā'mᴇq.
Tladēudrä'; Nîsk·a' : Wia'k·s (English : Tombstone Bay).
ǫugamautsiclak·ē'ga ; Nîsk·a' : Wilduwa'ntlgyat.
Tladēutsä'; Nîsk·a' : Tlgugyitlk·ā'ıntl.
Atlamatsēt'at'ä' ; Nîsk·a : Qā'dîk·c.
Gwēn ; Nîsk·a' : нgōnt.
Cadōuga' ; Nîsk·a' : Cadōuga'.

Names of Rivers emptying in Bay of Quadra, or Nekyehūdja'.

Atqatqaga'.
Nugufega'.
Tsêtliega'.
Tcū'naq : Chunah River.

Among these names two are worth a remark : Atlamatsēt'at'ä', on the west side of Portland Inlet, is so called on account of a localised tradition. It is said that in the beginning there were no mountain-goats. One day a man named Atlama went up the mountains and found a cave full of goats. He hid at the entrance of the cave and killed the goats when they came out, one after the other. He caught two kids, tied their legs, and carried them down to the camp. Therefore the place was called Atlamatsēt'at'ä'. The second place which is worth remarking is Cadōuga', because it has the same name in Nîsk·a', which shows that the Tinneh name was adopted by the intruding Nîsk·a'.



Illustrating the Tenth Report on the North-Western Tribes of Canada.

When the members of the tribe were reduced in numbers the Nîsk·a′ began to claim Portland Inlet as their territory, and 'Chief Mountain' monopolised the right of trading with the Ts'Ets'ā′ut. Since that time they have been called his slaves.

These reports on the former location of the tribe are corroborated by the fact that all their legends are localised either on Tcū′naq River, which seems to have been their principal haunt, or on Portland Inlet, and on rivers and lakes of the peninsula between Portland Inlet and Behm Channel.

I learned the following particulars in regard to their history.

According to the statements of Levi, they lived in olden times much more frequently on Behm Channel than on Portland Inlet. At that time they were on friendly terms with the Sā′nak·oan (Ssanghakŏn, Krause) of Boca de Quadra. The chief of the latter was their friend, and some of their number were in the habit of staying with the Sā′nak·oan. After his death the Sā′nak·oan intended to kill the Ts'Ets'ā′ut, and to enslave the women and children. The chief's nephews, however, informed them of this plan, and from that time they hunted more frequently around Portland Inlet. They then fell in, for the first time, with the Nîsk·a′ on Portland Inlet. The names of men whom they met there were K·aya′q, Gunā′q, and Gyitqō′n.

Three friends of the deceased chief of the Sā′nak·oan, whose names were Walk·En, Tlaqō′ns, and Qutk·a′, resolved to pursue the Ts'Ets'ā′ut, whose chief at that time was K·'acguēta′, a member of the Laqskī′yek clan. Tlaqō′ns and Qutk·a′ were brothers, and the last-named had married a K'utlk·oa′n woman. This tribe lived, at that time, on Revilla Gigedo Island, while nowadays they have joined the Sta′kink·oan. They are called by the Nîsk·a′ Gyitqā′êl. These three men followed the Ts'Ets'ā′ut. They found that they had made friends with the Nîsk·a′, and that most of them were hunting south of Nass River, near the village opposite Greenville, while some had gone to Observatory Inlet. They did not dare to follow them into the country of the Nîsk·a′, and turned back. They returned to Boca de Quadra, and went to a place which was owned by K·asā′qs, the chief of an eagle clan of the Sā′nak·oan. They call this place K·a′itl, while the Ts'Ets'ā′ut call the river which empties there Atqatqaga.′ This is the most southern of three rivers emptying in Quadra Bay. The middle one is called Nugufega′, the most northern one Tsêtliega′ in the Ts'Ets'ā′ut language. In the following autumn the Ts'Ets'ā′ut returned to the mouth of Atqatqaga′, and fell in with the Sā′nak·oan. The latter invited them to come down to the place where their fish was stored, which they proposed to exchange for skins. There were three Laqskī′yek men, three Laqkyebō′ women, and fourteen children in the party. They had three guns among them. Levi's uncle was one of the party. It was raining, and as soon as they reached the camp the Ts'Ets'ā′ut placed their guns over the fire in order to dry them. The Sā′nak·oan had loaded their guns outside. They had two long guns and one short one. A Tongass woman, who was married to one of the Sā′nak·oan, was friendly to the Ts'Ets'ā′ut, as were all the members of her tribe, and she cried all the time in order to warn them, but they did not understand what she meant. In order to provoke a quarrel Tlaqō′ns, who owned the short gun, asked one of the Ts'Ets'ā′ut if he thought that the gun would kill a bear. The Ts'Ets'ā′ut thought it was too small. Then Tlaqō′ns took the guns of the Ts'Ets'ā′ut, which were small-bore, from the drying frame, and, under pretence of examining them, placed them out of their reach. He said that his gun was wide-bore, and that he had only cut off the barrel in order to make it handier. He pretended to take offence at the deprecatory remarks of the Ts'ᴇts'ā'ut and shot him. At this signal his companions shot the other men. They took the bodies and the women and children in their canoe, and threw the former into the sea. When the Ts'ᴇts'ā'ut heard of what had happened, they went to Nass River in order to attack the Sā'nak·oan when they should come to buy olachen grease. But they did not dare to come for several years. From that time the Ts'ᴇts'ā'ut made Portland Inlet their headquarters. These events happened before Levi was born, *i.e.*, about sixty years ago. But the attacks of the Sā'nak·oan continued afterwards. Whenever one of their chiefs died, they tried to kill some of the Ts'ᴇts'ā'ut, and to obtain slaves from among their number.

At one time an uncle of Levi had run away with a girl whose parents refused to give her to him in marriage. At Halibut Bay he met a Nîsk·a', whom he requested to take him across the inlet. The Nîsk·a', who wanted to buy marmot skins, proposed to go back to Nass River to fetch powder and lead, and was going to return in order to take the couple across the inlet. In return the Ts'ᴇts'ā'ut was to catch for him a certain number of marmots. While he was away a canoe carrying three Nîsk·a' men (Gyitqo'n, a Laqskī'yek; Nēsqba'k·t, a Gyispawaduwᴇ'da; and Sīnatlô'ôt, a K·anha'da) landed. The Ts'ᴇts'ā'ut owed some marmot skins to the first of these men, who demanded immediate payment. The Ts'ᴇts'ā'ut explained that he had no skins, because he had run away with a girl, but Gyitqo'n did not listen. He got angry, and killed the Ts'ᴇts'ā'ut with his axe. The woman ran away, but Nēsqba'k·t shot and killed her. Then they buried them at the foot of a tree. After a while the first Nîsk·a' returned, but did not find the couple. When he saw their dog running about, he thought that the three men whom he had met might have killed them. He went to Tombstone Bay, where many Ts'ᴇts'ā'ut were encamped, in order to catch salmon. He took the dog along, and told them what had happened. Then all those who were encamped at the Bay, about fifty in number, struck camp because they became afraid of the Nîsk·a'. They were more willing to brave the attacks of the Sā'nak·oan than those of the more numerous Nîsk·a'.

One of the Sā'nak·oan had a Ts'ᴇts'ā'ut woman for his wife. They fell in with him, and he took them to the large island K'ā'tik' (Tlingit name; probably Revilla Gigedo Island). After some time the K'u'tlk·oan learned of their whereabouts and searched for them. When they had found them they wanted to remove them to the mainland. The Ts'ᴇts'ā'ut agreed to go, but during the night, while all were asleep, the K'u'tlk·oan produced their guns which they had hidden, and shot all the men and women. One of the Ts'ᴇts'ā'ut, who had a gun, was killed while he was aiming at one of their aggressors. They put the children into their canoe as slaves, but as there were too many of them they threw eight of their number into the sea. Thirty were enslaved.

Another quarrel took place about forty-five years ago. One winter, about the month of February, Levi's father and several other men went from Portland Inlet to Qā'itl, which is a river near Tcū'naq. They pitched their camp near the mouth of the river. After some time one man and his wife saw a canoe coming. When the canoe landed they saw that several Sā'nak·oan were in it. The latter gave them tobacco, powder, and balls, and inquired for their camp. After they had learned where it was, they promised to call there on the following day. The Sā′nak·oan camped in the entrance of a small bay. On the following morning they went to the camp of the Ts′ᴇts′ā′ut, and after having eaten they began to trade, the Sā′nak·oan buying skins for tobacco, powder, lead, and shirts. On the following morning two Sā′nak·oan brothers, K·atsē′el and Yaqtē′it, remarked that there were many crows on the beach, and took up their guns in order to shoot them. After a short while they re-entered the hut, one of them holding his gun under his blanket. He aimed at one of the Ts′ᴇts′ā′ut, hiding his gun under his blanket all the time, and shot him. At this signal his brother shot another man, and a third of the Sā′nak·oan, whose names were K·ahotê′ and Nag·atsê′ (Fox), shot a third man. The others drew their daggers, and killed all the Ts′ᴇts′ā′ut men. They enslaved the women and children, and took them to Revilla Gigedo Island, where they stayed the rest of the winter. In the spring of the year Levi's mother made good her escape, taking her two children along. She made a bark canoe, crossed Behm Channel, and after two months of hardships they reached Tombstone Bay, on Portland Inlet, where they met the Ts′ᴇts′ā′ut who had stayed on the inlet. 'Eve,' who is old now, was sold at that time to the Skêtk·oa′n, from whom she escaped.

At another time, while Levi was a boy, the Ts′ᴇts′ā′ut had a war with the Laq′uyî′p. At that time his sister had just married a man named Nᴇgusts′ikatsa′. They were hunting north of the upper reaches of Nass River. When they returned to Portland Inlet a party of Laq′uyî′p came there accompanying a Ts′ᴇts′ā′ut hunter. The Ts′ᴇts′ā′ut had one gun among them, and were about to shoot at the Laq′uyî′p when their countryman asked them to desist, as the Lag′uyî′p had come to make peace and to pay for those who had been killed in previous wars. The Ts′ᴇts′ā′ut allowed them to approach and gave them to eat. When they were about to go to bed they showed the Laq′uyî′p their gun. One of the latter kept it, and in the ensuing quarrel he shot two of the Ts′ᴇts′ā′ut. Levi added here that in olden times his countrymen were 'as stupid as ghosts.'

These historical data define their territory fairly well.[1]

[1] Mr. J. W. McKay on hearing indirectly of my researches at Portland Inlet published in a journal which commands some authority in Canada (*The Province*, Victoria, B.C., December 29, 1894) a correction before any of my observations were made public. He says that these Indians 'belong to the Kunânâ, a tribe which inhabits the lower Stikine Valley, and whose headquarters are at Tahltan, on the first north fork of the Stikine River. About forty years ago three or four families of these Indians were hunting in the neighbourhood of the head waters of the Skoot (Iskoot), a large tributary of the Stikine. Game was scarce, the prospect of a hard winter stared them in the face; they accordingly decided to make for Chunah, on the seacoast, at the head of Behm Inlet. They took a wrong direction and struck the coast on the west shore of Portland Channel. They were then discovered by one of the headmen of the Naas tribe, who arranged with them to protect them from molestation provided that they sold all the product of their fur hunts to him at his price. Having no alternative but to accept his proposition, or be sold into slavery, they agreed to be his vassals, and have remained as such to his heirs and assigns to this day. They are not the remnants of a tribe; they belong to a tribe which still maintains its normal strength in the valley of the Stikine.'

In a letter addressed to Dr. G. M. Dawson and dated Victoria, B.C., January 19, 1895, Mr. McKay makes the following additional statement:—

'I have your letter of the 6th instant touching Dr. Boas's discovery of a remnant of a tribe of Indians on Portland Canal. The facts of the case are substantially as stated in *The Province*, and were made known to me incidentally during my sojourn in Cassiar.

'I was one day encamped near the Tahltan River when some Naas Indians came

In regard to the personal appearance of the Ts'Ets'ā'ut I refer to the measurements contained in the first part of this report. The individuals whom I saw were short, of light colour, with broad and flat faces and low noses. Their mouths were full. Their general appearance is very much like that of the Nîsk·a'.

They have no fixed villages, but make a camp wherever they intend to hunt. Their staple food is porcupine, marmot, mountain-goat, and bear. The skins of these animals supply the material for clothing. In summer they go down the rivers of Portland Inlet to catch salmon, which they dry for winter use

At present they wear white man's clothing, but according to Levi's descriptions their old style clothing corresponded to that of other Tinneh tribes. Both sexes wore high boots (kuê) made of marmot skins and reaching to the thighs, and pants (ēk!ayê) made of curried skins. Men wore a leather jacket (ayā'n) cut like a shirt and reaching to the middle of the thigh. In winter they wore a jacket of marmot skins with mittens attached (agōtsqa') and threw a robe of birdskins (tss'ä) over their shoulders. In travelling they tied the robe around their waists by means of a belt (sê). Women wore a short coat, which was tied around the waist (atlaê'), and a jacket (tl'ā), both being made of mountain-goat skins. The skin of the belly of the beaver was also used for the manufacture of clothing. In recent times both sexes have adopted the use of the moccasin

into my camp and complained that Na-nok, the chief of the Tahltan Ku-nâ-nās, would not let them proceed to Dease Lake unless they paid him something for passing through his country. I had with me at the time as servant one Jim, a Ku-nâ-nā Indian, who explained the cause of Na-nok's conduct by detailing the statement published in *The Province*. I made Na-nok understand that he must not make reprisals; that his tribesmen at Portland Inlet had full liberty to return to their own country if they wished; that his jurisdiction did not extend to levying tolls on strangers passing through the country, in which he himself was only a sojourner, as he had done nothing to improve it; and that he must let the Naas Indians pass, which he accordingly did. This happened about twenty years ago.

'As to the original inhabitants of Portland Inlet the most ancient of which we have any account is the Tongas band of the Tlinkeet tribe. The wintering villages of this band at one time extended as far south as Mâh-lit-hāh-lâ; they were driven northward by two (Metlakathla) hordes of Tsimsians (men of the river) who descended from the interior by the valleys of the Skeena and Naas, took possession of the Tsimpshian Peninsula, and settled thereon. The Tongas, being forced to relinquish their rights therein, retired to the coast and islands immediately north of the entrance to Portland Canal. If there were any inhabitants in Portland Inlet when the Tlinkeets first reached that locality, they would have been exterminated or otherwise absorbed by the latter race before the Tsimshian race made its appearance on the scene of action. The Tongas would be the most likely Indians to give what information may be obtainable respecting any race more ancient than themselves, which may have existed in the locality under consideration. The Tlinkeets of Cape Fox might also be able to throw some light on the subject.

'You are aware that the Ku-nâ-nās of the Stikine Valley are closely allied to the Tlinkeets of that section, *i.e.* the Skat-kwan. The Skat-kwan are closely allied to the Tongas, and these facts may account for the Naas Indians' moderate treatment of the little band of Ku-nâ-nās who unfortunately tumbled, as it were, into the lands of the stranger, and stranger meant enemy in the days and in the country of which I am writing. Had they reached *Chunah*, at the head of the Behm Canal, the point for which they were making, they would have been amongst their friends the Skat-kwan Tlinkeets.'

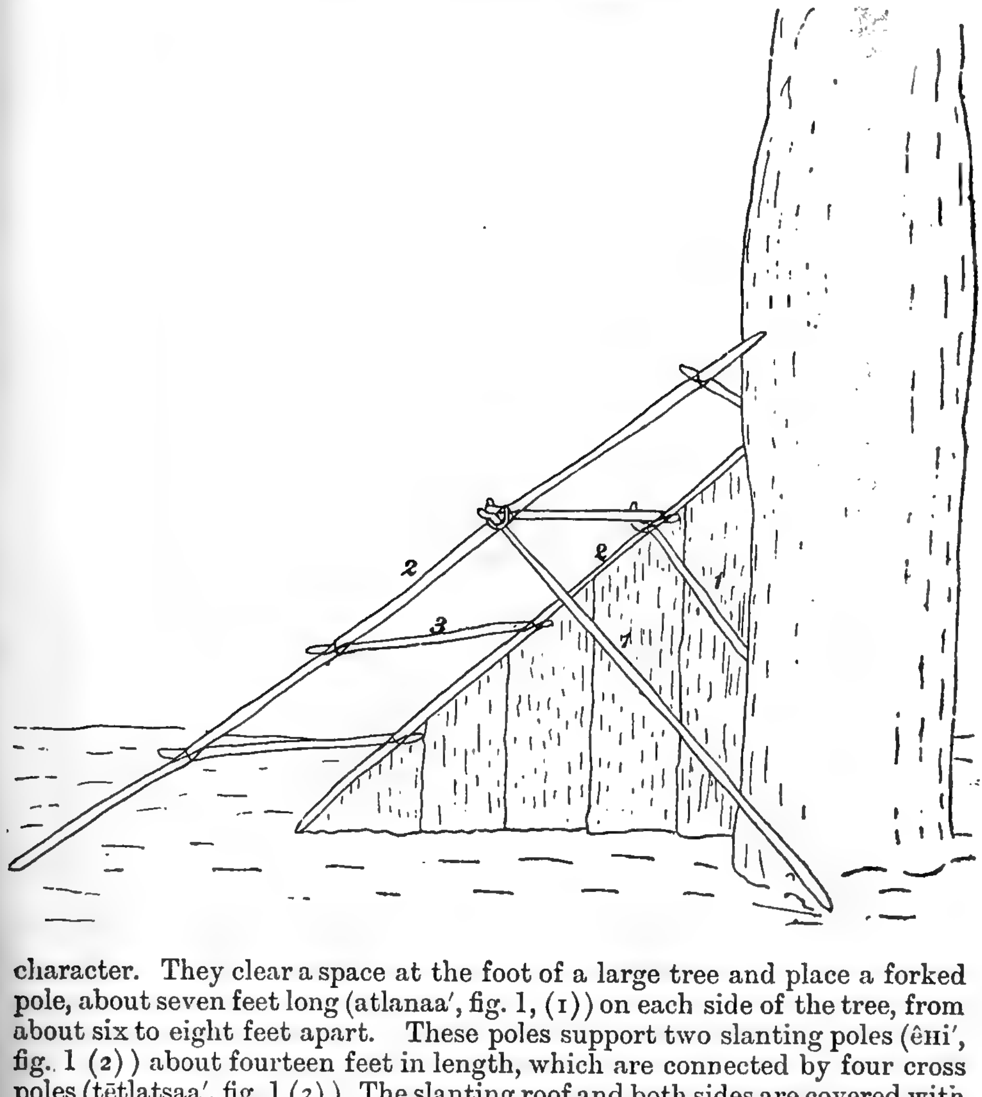
There is no traditional evidence of the invasion of the Tsimshian tribe to which Mr. McKay refers, although it is probable that the Tsimshian were originally an inland people. The statements collected by me show also that Mr. McKay is mistaken in regard to his notions of the distribution of tribes in Southern Alaska.

(kêcikatssē) in place of the high boot. It is made of mountain-goat hide. The hair was tied in a knot behind the head, while the Tatltan (Tahl-tan) shaved their heads.

They wore ear-ornaments made of the wool of the mountain goat. These were attached to holes made in the lobe and in the helix. The nose was also perforated, and ornaments made of haliotis shells or of coins were suspended from the septum. The clothing was embroidered with porcupine quills. Before the introduction of glass beads they made beads of bone. Girls wore hats (see p. 566).

The houses of the Ts'ᴇts'ā'ut are made of bark, and are of a very temporary

FIG. 1.—Hut of the Ts'ᴇts'ā'ut.

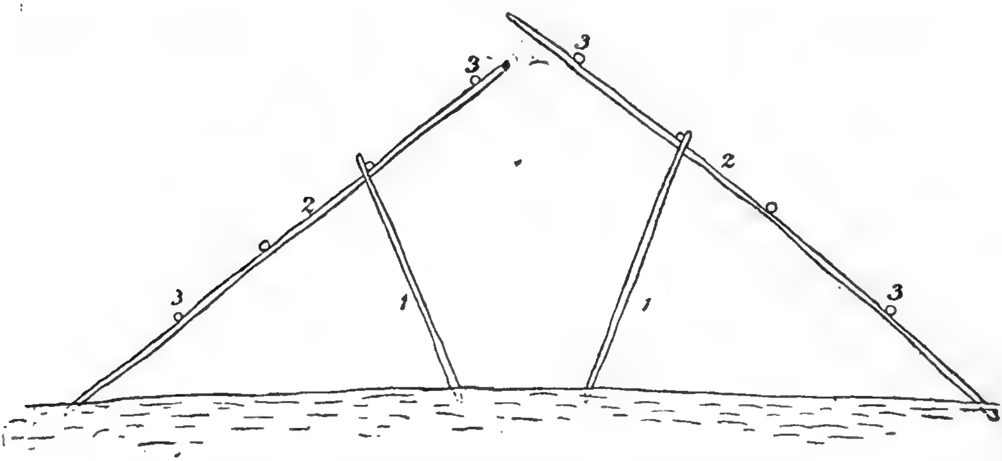


character. They clear a space at the foot of a large tree and place a forked pole, about seven feet long (atlanaa', fig. 1, (1)) on each side of the tree, from about six to eight feet apart. These poles support two slanting poles (êнi', fig. 1 (2)) about fourteen feet in length, which are connected by four cross poles (tētlatsaa', fig. 1 (3)). The slanting roof and both sides are covered with bark, while the end next to the tree remains open. Sometimes one side next to the tree is closed; the other serves as a doorway. The fireplace (khō da tla) is at the foot of the tree; the smoke escapes at the open top next to the trunk of the tree. The ground is covered with brushes, and the bed is spread at the low end of the hut, the head end being at the side remote from the tree. The structure is lashed together.

When two families desire to inhabit one house, two of these structures are joined together, so that they stand end to end, and one is built a little higher than the other (fig. 2). Thus the roof of one side overlaps that of the other and prevents the entrance of rain. This house has a door on each vertical side. It is also built close to the butt of a tree as a protection against snow and rain, the trunk of the tree being close to one of the vertical sides. When the tribe moves to another camp the houses are taken apart and the poles are tied together and to a tree. When the party returns to the same place they untie the bundle and use the same poles.

In winter the poles are tied more strongly, and very stout supports are selected. When the snowfall is very deep the doors are blocked up and the exit is through the roof. It would seem very likely that this winter house may be the primitive form out of which the subterranean

FIG. 2.—Double hut of the Ts'Ets'ā'ut.



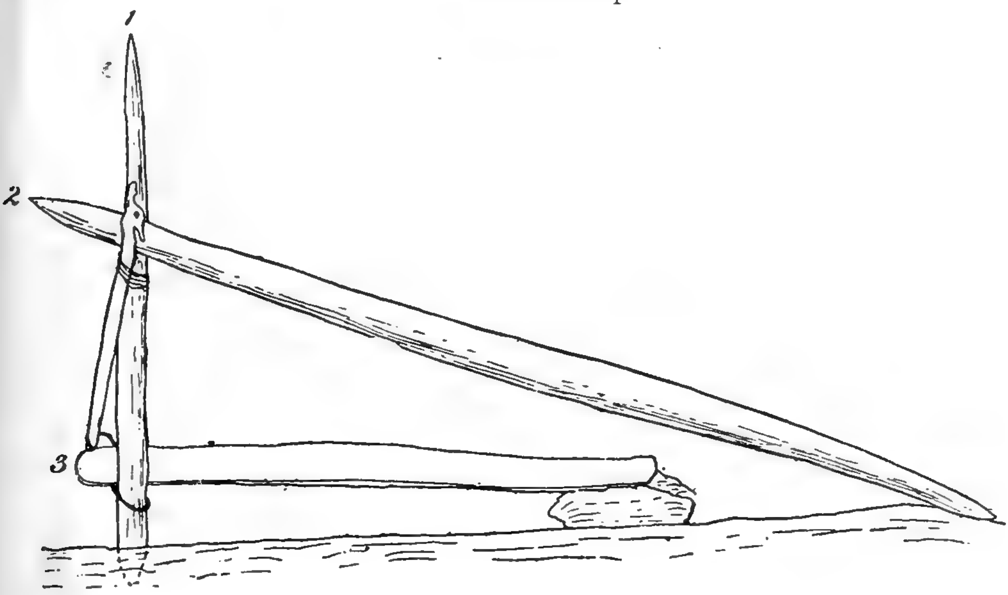
lodge of the interior of British Columbia may have developed. The advantage of covering the walls with dirt instead of waiting for a snowfall, to ensure protection against winds and cold, would become easily apparent, and then the ground plan of the two houses would become very much alike. The advantages of the bilateral arrangement would also disappear when the houses were built underground instead of overground. I would remark at this place that the supports of the subterranean lodge are slanting outward, not vertical, as indicated on page 633 of the Sixth Report of the Committee, and that Dr. Dawson's figure ('Transactions of the Royal Society of Canada,' 1893, ii.) renders the plan correctly.

The bed is covered with mats made of cedar-bark. Quilts or blankets are made of the skins of goats, bear, and marmot. Baskets are used for cooking and for carrying water, berries, and other kinds of food. They are made of spruce roots or of bark. Spoons are made of bark or of mountain-goat horn. Axes and adzes were made of bone or horn.

Fire was made either by means of the firedrill or with a strike-a-light. The stone for the latter is found in Tombstone Bay, but the description of the kind of stone was too indefinite for the purpose of identification.

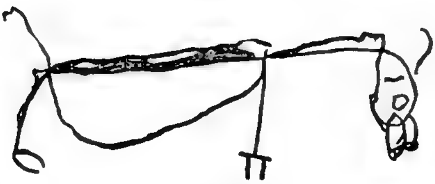
The firedrill is turned by means of a bow : the upper end is held in a piece of bark, while the lower ends turns in a slit of a piece of wood. Dry rotten wood is used for tinder. The sinew-backed bow was made of yew wood. There was a stud on the inner side, which served to keep the string from the bow. The string was made of the skin of the back of the beaver, which was cut into strips and twisted. One end was tied to the end of the bow, while the other had an eye which was hung over the other end. Bows of this description are used by the Kenai and the Tinneh of the Lower Yukon River. The arrow was made of yellow cedar and winged with eagle feathers. Flint for arrow-heads was obtained from a place in the mountains north of Laq'uyîp'. It is said that the people made expeditions for obtaining this material, which lasted two years. The bow is held horizontally. The arrow is grasped by the bent first finger and thumb of the right hand. Sometimes the bow is held vertically.

FIG. 3.—Marmot trap.



Then the arrow is grasped by the thumb and first and second fingers of the right hand, and rests between the first and second fingers of the left. When hunting they carry their small game in pouches. In winter they travel on snow-shoes, the netting of which is made of beaver skin. For mountain climbing they use a pole about three fathoms long (tqê). Marmots are caught by means of traps of simple construction (fig. 3). A stick, the end of which is carved in the shape of a blue jay, crane, or some other animal, is tied to a longer stick, which is placed upright in the ground (1). A heavy club-shaped stick (2) is laid over the place where the two sticks are tied together, pressing on the head of the carved stick. The lower end of the latter is held to stick 1 by means of a loop. The lower end of the stick 2 is loaded with heavy stones. A small flat stick or board (3) is placed over the loop, and lies in the entrance to the marmot hole. This board is covered with dirt and grass, and as soon as the animal steps on it the loop slips down stick 1, the heavy stick falls down and breaks its back. All these sticks are painted red, and are then covered with stones and grass. They also bear property marks. Figures are also engraved on stick 1. Some of them are reproduced here (fig. 4). No. 1 represents the mountain-goat browsing, No. 2 the blue grouse, No. 3 the pigeon, No. 4 is a man holding a lance in the act of killing a bear. His nose is indicated by two spots; the black lines in the

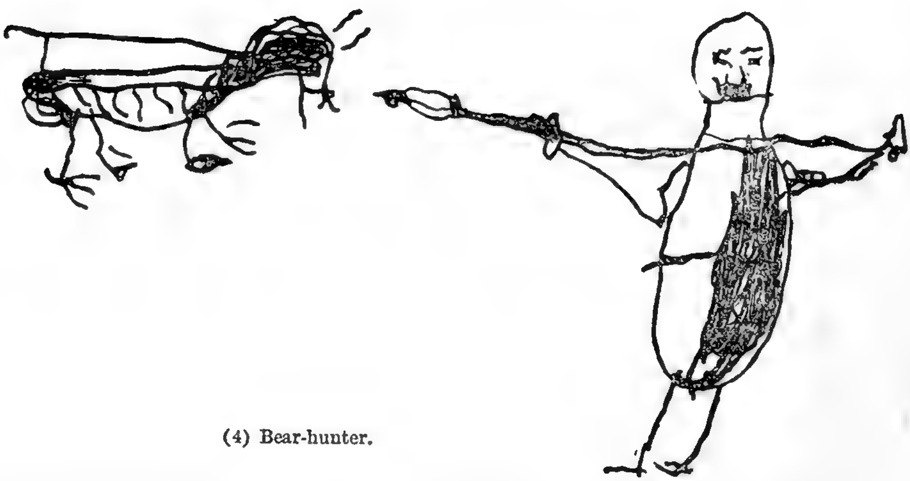
FIG. 4.—Figures engraved on traps.



(1) Mountain Goat.

(2) Grouse.

(3) Pigeon.



(4) Bear-hunter.

body represent the backbone. The position of these lines shows that the body is represented as being turned towards the bear. The two lines near the back of the bear are also the backbone; the lines descending from it are the ribs. Its mouth is open.

Porcupines are hunted during the nighttime. They are not caught in traps, but killed with lances, clubs, or arrows. It seems that they do not use nets for catching rabbits. Levi said that the Laq'uyî'p hunted in this manner, but that the Ts'Ets'ā'ut did not do so. They always hunt singly, one man confining his operations to one valley at a time. They use canoes to a slight extent only. The canoes were made of the bark of the yellow cedar. They were about three fathoms long. The bark is stripped all around the tree. Then it is stretched, sewed in the proper shape, and the seams and holes are calked with gum. They used sails which were made of marmot skins.

In winter they live to a great extent upon meat dried during the summer months. The staple food is marmot meat, which is mixed with marmot grease, boiled and preserved in marmot guts.

The tribe consisted of two clans, the Eagle and the Wolf. Only members of the Wolf clan survive. The native names of the clans are lost, and they are called by their Nîsk·a equivalents, Laqskī'yek and Laqkyebō'. The equivalent of the latter among the Sā'nak·oan are the Tēk·oēdē. The clans are exogamic. As members of one clan only survive, all the married Ts'Ets'ā'ut of this time have married members of foreign tribes. Each clan has separate names. I obtained names of the Laqkyebō' only.

Men.	Women.
DrEntsElê'.	Atlaâdzē'.
Qatlō'.	Cêtlgwē'uk.
Gwaya'.	
Tsîkyatsa'.	
Tsātso'.	
Cān.	
Nadzē'.	

The institutions are maternal, succession being in the female line. The child inherits from his mother's brother. We find among the Ts'Ets'ā'ut also the institution of avoidance between mother-in-law and son-in law (matuōHa') which is found among all the northern Tinneh tribes. Levi explained that they were ashamed to talk to each other, and even to see each other. The mother-in-law leaves the house before the son-in-law enters, or, if such is impossible, she hides her face or turns the other way while he is near her. Levi stated that the adult man must also not look at his adult sister. This custom, he explained, is based on a tradition according to which a man married his sister. Their brothers were ashamed, tied them together, and deserted them ; but the man broke the ropes. They had a child, and eventually he killed a ram, a ewe, and a kid of the mountain-goat, put on their skins, and they assumed the shape of goats. He had acquired the power of killing everything by a glance of his eyes. One day his tribe came up the river for the purpose of hunting, and he killed them. Then he travelled all over the world, leaving signs of his presence everywhere, such as remarkable rocks. The woman and her child went to the head waters of the Nass River, where they still continue to live on a lake.

I also found the Tinneh custom according to which the parents of a child change their names and adopt that of father or mother of so-and-so. In this case at least the custom must be interpreted somewhat differently from the way in which it is usually done. There are a limited number of names only in the tribe, probably names belonging to the nobility. When a child reaches a certain age, his father, uncle, mother, or aunt may give it his or her name; and since by this act the former owner has relinquished his place, he also loses the name belonging to the place, and consequently adopts that of the father, mother, or aunt of the owner of the place, thus indicating that he owned the place formerly.

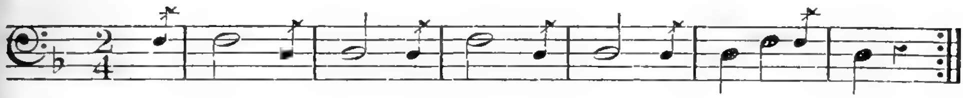
When a woman is about to give birth to a child a separate hut is built for her. When the child is being born two other women hold a stick horizontally in front of the mother. She takes hold of it, standing in a bent position. A third woman takes hold of the child, covering its mouth until it is born. The navel-string is tied with sinews, placed on a stick, and then cut. The mother rests for a day, then she takes up her usual occupation. After a boy is born the father must not cut off the legs of any kind of male game; after a girl is born he must not cut off those of female game, else the private parts of the child would swell.

A girl when reaching maturity wears a neck-ring of crabapple twigs (k·!asē'l), earrings of bone, and a piece of a rib around the neck, as amulets to secure good luck and a long life. She also wears a large skin hat which comes down over her face, and prevents the sun from striking it. If she should expose her face to the sun or to the sky, it would rain. The hat protects her face also against the fire, which must not strike her skin. For this purpose she also wears skin mittens. She wears the tooth of an animal in her mouth to prevent her teeth from getting hollow. For a whole year she must not see blood unless her face is blackened, else she would grow blind. For two years she wears the hat and lives in a hut by herself, although she is permitted to see others. After that period a man takes the hat off from her head and throws it away.

When a young man desires to marry a girl he asks her parents, to whom he gives presents of meat at intervals during a year. Then the bride's parents invite him and his clan to a feast at which the marriage is celebrated. When a man dies and leaves a widow his brother marries her. He provides for her during the period of her widowhood. He must not marry her before the lapse of a certain time, as her husband's ghost stays with her and as the ghost would do him harm. The widow and also the widower eat out of a stone dish. She or he carries a pebble in the mouth, and a straight crabapple stick is placed along the back, inside the jacket. She sits upright day and night. The meaning of this custom is that her back shall remain as straight as the crabapple stick even in her old age. The deceased husband's brother must take care that everything is quiet in the widow's house. Any person who crosses the hut in front of her dies. She fasts for two or three days after the death of her husband. After that she is allowed to eat what she pleases. When a woman dies and her husband survives, he marries her sister.

Men must not cut their hair, else they would grow old quickly. Men and women do not eat the heads of mountain goats, else their hair would turn grey early.

In cases of sickness the shaman is called. He sings certain songs. He does not use a rattle, but only a feather wand, generally an eagle's tail. His hands and his face are painted red. He fans and blows the patient or blows water on to him. Then he takes the disease out of him with both hands, acting as though he dipped it out, and blows it into the air. He uses a square drum consisting of a frame over which a skin is stretched. The four corners of the frame are connected by thongs. Here is a shaman's song:—



I add a dancing song :—

When a person is about to die his friends leave the house and desert him. Everything that is in the house is left behind. They are afraid of ghosts and avoid returning to the same place. Sometimes the body is placed in a hollow tree and stones are piled up in front of the entrance, or the butt of a tree is hollowed out on purpose. The knees of the body are doubled up so that they touch the chin. The relatives of the deceased cut their hair.

The ceremonial after the death of a chief is somewhat elaborate. The body is burnt by the clan of which the deceased is not a member. The chief's clan fast for three days. On the fourth day they partake of a little water and raw food. On the fifth day they prepare a feast in honour of their deceased chief. During the feast some food is burnt for him. Those who buried the body receive blankets in payment. After they have finished eating they begin to dance. The mourners sit down around a fire wailing. They wear mittens and cover their mouths with their hands that the fire may not strike them. The same ceremony is repeated three times ; the second time from the fifth to the tenth day, and the third time from the eleventh to the fifteenth day after the death of the chief ; then they are clean. During all this time they do not undress, and keep their hats on. Every morning they wash in sour urine and put fresh coal on their faces.

The following tradition illustrates the beliefs of the Ts'ᴇts'ā'ut in regard to the abode of the soul after death. 'A widow who was with child was killed by a branch striking her abdomen. Before dying she gave birth to two girls. Her sister adopted the children and reared them. In the spring of the year the tribe went up Portland Inlet to catch olachen. The woman with her two children could not travel as quickly as the others did and lagged behind. One night she was unable to reach the camp of the tribe, and when it grew dark she made a hut and camped with the two girls. They had nothing to eat and the children were crying. After some time they fell asleep. All of a sudden the woman awoke, and on looking around found herself in a village. It was a beautiful village. There were two rows of huts, one on each side of a river. She entered a house and saw her sister and her sister's husband. Then she knew that she was in the village of the ghosts. She began to cry and her sister cried with her. She told her sister that she had not been able to follow the tribe and that she and the children were starving. Then the ghost left the house and re-entered carrying a bag of marmot-guts filled with marmot meat and grease. She gave the bag and a dish to her sister to take them home. She told her that the meat would last her a long time. The woman took the bag and the dish and went home. The trail led up the river through a beautiful valley. Finally she came to a pass leading across the mountains. As soon as she reached this place she fainted. When she awoke she found herself in her hut. The two girls were asleep, and the bag and the dish which the ghost had given her stood next to them. She gave them some meat and told them that she had been to the village of the ghosts who had given her provisions. The next morning they proceeded on their journey and finally reached the tribe. The meat in the bag did not grow less although they were using it all the time. She told the people of her adventure and showed them the dish, which differed in shape from the dishes of the Ts'ᴇts'ā'ut. They lived on the meat for a whole year and it did not grow less. The girls became stout because they were always well nourished. The aunt and the two girls married. After some time the aunt's husband was lost when hunting porcupine. When he did not return the people went to look for him, but they could not find him. On returning they told the widow to go once more to the village of the ghosts in order to see if her husband were dead. She lay down to sleep, and when she awoke she found herself on the pass which she had crossed before. She saw the village down below in a beautiful valley on both sides of a river. While it was winter on earth it was summer here. She reached the village and entered her sister's hut. She told her that she herself and her nieces had married and that she had come to look for her lost husband. Then her sister cried and told her that her husband was in the hut next door where he stayed with his parents. The woman said: "He took a belt and a marmot-skin blanket away which belong to my child. I wish to take them home." Her sister replied: "He had them on when I saw him." Then the woman went into the hut next door and found her husband lying near the fire. She saw his parents and others of his deceased relatives. Then she asked him for the belt and the blanket, and he gave them to her. He also told her the place where his body was lying. It was at the foot of a mountain where they had camped before. There was a little boy in the hut who ran up and down in front of the woman. She grew angry and pushed him so that he fell into the fire. He vanished, for if a ghost is killed, he is destroyed entirely and he ceases to exist. The woman ran out of the house and at once she awoke in her own hut. It was early in the morning. The blanket lay next to her. The belt was on the ground, but one half of it was still in the ground and the people were unable to pull it out. She reported what her husband had told her, and when the people went to look for the body of her husband they found it at the place indicated by the ghost. The head was frozen to the ice, while the lower part of the body was moving. They tried to free it from the ice, but they were unable to do so. Then they cut wood and burnt the body right where it lay.'

I did not obtain much information in regard to their games and pastimes. Levi insisted that he had never seen a Ts'ᴇts'ā'ut gambling and knew only a game at ball played with a ball of cedar-bark, and the game of cat's-cradle. Hunters, who desire to secure good luck, fast and wash their bodies with ginger-root for three or four days and do not touch a woman for two or three months. They drink decoctions of 'devil's club' for purposes of purification and for securing good luck.

Their traditions are remarkable on account of the slight influence of the coast tribes upon them. The Rev. F. Maurice has pointed out that the customs and traditions of the Tinneh of the interior of British Columbia, namely, of the Chilcotin, Carrier, and Siccanie, have been influenced to a considerable extent by the coast tribes.[1]

The mythology of the Ts'Ets'ā'ut agrees closely with that of the northern and eastern Tinneh tribes, which were studied by E. Petitot. Without entering into details I will mention a few of the fundamental traits of their traditions. The earth was originally level: it was hot, there was neither water, rain, snow, fog, nor wind. The animals were starving and tore the sky, went up and liberated rain, snow, and wind, which were kept in bags in the house of the goose woman. Rivers originated when a man, in order to obtain water, shot an arrow into the ground, whereupon a spring welled up. Mountains originated when two brothers flew from their giant wives, who pursued them. In order to obstruct their progress they threw the contents of the stomach of a cariboo upon the ground. These were transformed into mountains and valleys. Later on a flood destroyed all the people: only children of two clans survived, who were placed by their parents inside two trees. The fire was originally in possession of the grizzly bear, who wore a strike-a-light as an ear-ornament. A bird stole it and brought the stones to men. Glaciers and snow on the mountains are the remains of an immense snowfall which covered the whole world. There are a great many traditions telling of the marriage of men to women who were animals or other beings. A people of cannibals of human form, but with faces of dogs, called Qudä'lê, and giants called Tsūfa', are the subjects of many tales.

IV. The Nass River Indians, the Nîsk·a'.

The customs of the Nîsk·a' and those of the Tsimshian, which were described in the Fifth Report of the Committee, are practically identical. Therefore I will not enter into a detailed description of this tribe, but give such data only as supplement my previous notes. The Nîsk·a' speak one of the three main dialects of the Tsimshian language; the other dialects are the Tsimshian and the Gyitkshan. They inhabit Nass River, except its upper course. Nowadays they live in a great many permanent villages, but formerly only four subdivisions were recognised by them. Laqk·'altsa'p (=at the town), Andegualē', Gyîtwunksē'tlk, and Gyît'-laqdā'mîks. I mentioned in my former report that the Tsimshian are divided into four clans: The K·anha'da, or Raven; the Laqkyebō', or Wolf; the Laqskī'yek, or Eagle; and the GyispawaduwE'da,[2] or Bear.

I discovered that these clans are subdivided or specialised, there being families of the clan at large, and subdivisions of the clan. Among the Nîsk·a' and Gyitksha'n I found the following subdivisions:—

[1] The Rev. F. Maurice misunderstands me when he assumes that I think the coast people have not influenced the tribes of the interior. This influence is apparent in all the descriptions of former travellers, and has been admirably demonstrated by Mr. Maurice. But the reverse influence exists also, and has affected to the greatest extent the Tlingit tribes who trade with the interior, the Tsimshian, the Bilqula, and the Salish of the interior. The flood legends which refer to the finding of the earth by the musk rat, some of the burial customs and inventions, must have percolated through these channels, even if the Tinneh tribes have lost some of those customs owing to secondary changes.

[2] This spelling is more correct than GyispotuwE'da, as given formerly.

I. K·anha′da : Raven.

1. GyîtHk·'adô′k·
2. Laqsē′el =on the ocean.

II. Laqkyebō : Wolf.

1. Laqt'iâ′k·tl.
2. Gyîtgyîgyē′niH.
3. Gyîtwulnaky'ē′l.

III. Laqskī′yek : Eagle.

1. Gyisk·ab'Enā′q.
2. Laqlō′ukst.
3. Gyits'ä′Ek·.
4. Laqts'Emē′liH=on the beaver.

IV. GyispawaduwE′da : Bear.

1. Gyîsg·'ahā′st=grass people.

These totemic subdivisions are not represented in all the villages of the tribe, but are found as follows :—

I. Laqk·'altsa′p.

Raven : K·anha′da, GyîtHk·'adô′k·.
Wolf : Laqkyebō′.
Eagle : Laqskī′yek, Gyisk·ab'Enā′q.

II. Andegualē′.

Raven : Laqsē′el.
Wolf : Gyîtgyîgyē′niH.

III. Gyîtwunksē′tlk.

Wolf : Laqt'iâ′k·tl.
Eagle : Laqlō′ukst, Gyits'ä′Ek·.
Bear : GyîsG·'ahā′st.

IV. Gyît'laqdā′mîks.

Raven : Laqsē′el.
Wolf : Gyîtwulnaky'ē′l.
Eagle : Laqskī′yek, Laqts'Emē′lîH.

These are the old recognised subdivisions of the Nîsk·a′ which were given to me by 'Chief Mountain,' and corroborated in part by other members of the tribe. It is remarkable that in olden times the GyispawaduwE′da, who are nowadays the most numerous clan, appear confined to a single village. It is possible that the clan became more numerous owing to intermarriage with the Tsimshian.

Turning towards Skeena River we find the Gyîtwuntlkō′l, who are considered a separate tribe, and whose dialect is intermediate between the Nîsk·a′ and the Gyitkshan. They have two clans: the K·anha′da and Laqkyebō′.

'Chief Mountain' gave me the following subdivisions of the Gyikshan; the list is, however, incomplete:—

I. Gyitwung·ā′.

Raven: K·anha′da.
Eagle: Laqskī′yek.

II. Gyitsigyu′ktla.

Raven: K·anha′da.
Bear: Gyîsg·′ā′hast.

III. Gyîspayô′kc.

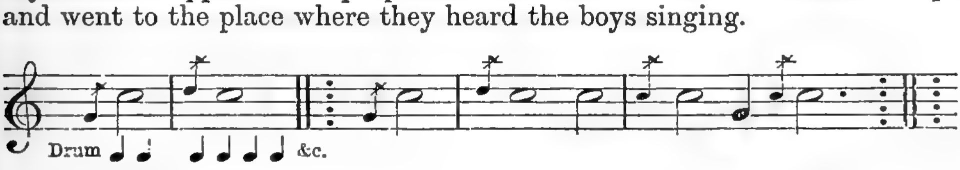
Raven: K·anha′da.
Wolf: Laqkyebō.′

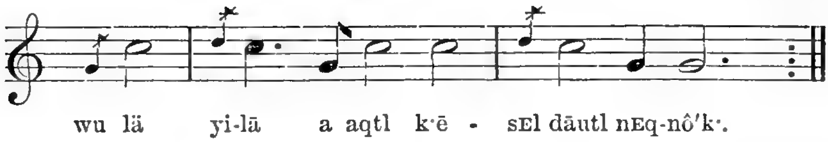
IV. Gyît′anmā′kys.

The subdivisions of a clan cannot intermarry with the main clan or with any other of its subdivisions. The people form four exogamic groups only: Raven, Wolf, Eagle, and Bear. Of these the Bear is considered the noblest clan, because it derives its origin from Heaven.

In all festivals the totems of the clan play an important part. Carvings representing the totem are worn as masks or head-dresses; they are painted or carved on houses and utensils, and on memorial columns and totem poles. In all initiations an artificial totem animal brings back the novice. I made particular inquiries regarding the meaning of masks and carvings, and the modes of their use. I shall next give what new information I obtained on these points.

When the GyitHk·′adô′k· branch of the K·anha′da have a potlach, three masks make their appearance, one of which has a moustache and represents a young man named Gyitgoô′yîm, while the other two are called Cā′câ. They represent the following tradition. While the people were staying at the fishing village Gulgyē′utl, the boys under the leadership of a young man named Gyitgoô′yîm made a small house in the woods behind the town. They took a spring salmon along and played with it until it was rotten. They caught small fish in the creek and split and dried them. They made small drums and began to sing and to dance. For four days they stayed there, dancing all the time. Then they became supernatural beings. Gyîtgoô′yim's hair had turned into crystal and copper. The people were about to move to another camp, and went to the place where they heard the boys singing.

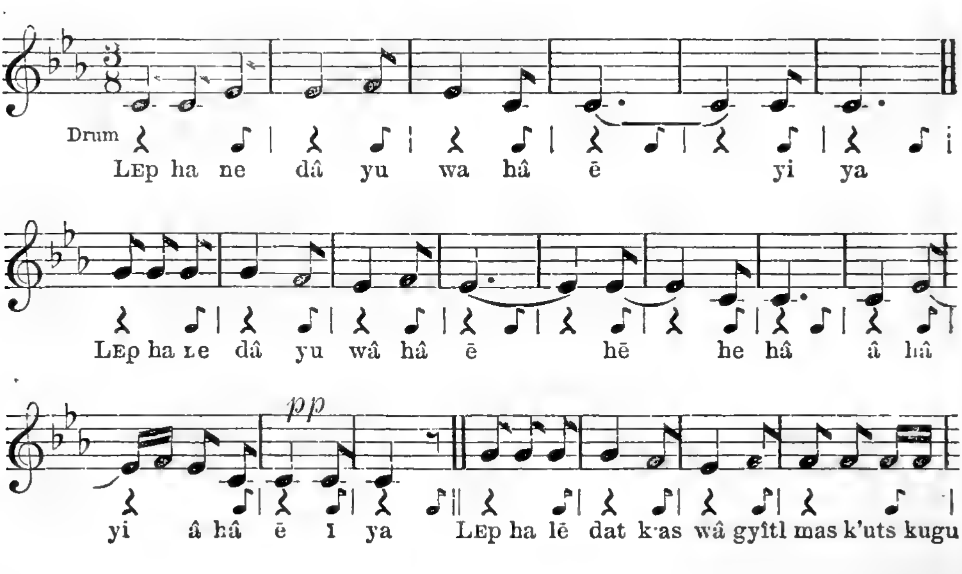




I.e. Where the copper hair, when the ice hair, is spread out, is the supernatural being.

As soon as the people approached them they disappeared and were seen at once dancing and singing at a distant place. They were unable to reach them. Then they returned, and since that time they have used the song and dance of these boys.

The GyispawaduwE'da have one head-dress representing an owl (*Māskutgunu'ks*) surrounded by many small human heads called *gyadEm tlak·s* (claw-men). This is worn in potlaches and commemorates the following tradition. A chief at T'Emlaq'ā'mt had a son who was crying all the time. His father became impatient and sent him out of the house saying, 'The white owl shall fetch you.' The boy went out, accompanied by his sister. Then the owl came and carried the girl to the top of a tree. The people heard her crying and tried to take her down, but they were unable to climb the tree. After a while she ceased to cry and married the owl. They had a son. When he grew up she told her husband that she desired to send her son home. Then his father made a song for him. His mother told him to carve a head-dress in the shape of an owl for use in his dance and to sing the song which his father had made for him. She bade him good-bye and said that her husband was about to carry her to a far-off country. The owl carried both of them to the old chief's house. When his wife saw the unknown boy she was afraid, but her daughter addressed her, saying that the boy was her grandson. Then the old woman took him into her house while the boy's mother and the owl disappeared. When the boy was grown up his mother's brother gave a potlach, and before the blankets were distributed the boy danced, wearing the owl head-dress and singing the song which his father had made for him.



I.e. My! brother this tree is my seat.

Some of the dances are actual mimical representations of myths. In one ceremony two men dressed like Ts'ᴇts'ā'ut hunters appear. Suddenly the noise of thunder is heard, and down through the roof comes a person dressed in eagle skins and wearing the mask of the thunder bird. The Ts'ᴇts'ā'ut shoot at the bird. At once there is a flash of lightning and a clap of thunder: one of the men falls dead and the other one escapes The fire is extinguished by means of water, which wells up through a pipe of kelp which is laid underground and empties into the fire. At the same time water is thrown upon the spectators through the roof. This performance is accompanied by the song of the women, who sit on three platforms in the rear of the house. The song relates to the myth which is represented in the performance.

Burial.—The burial is attended to by members of the clan of the father of the deceased, who are paid for their services. Four or five men bend the head of the body down and his knees up. Thus he is placed in a box. Chiefs lie in state for some days, while others are buried without delay. They burn food and clothing for the deceased, saying that it is intended for him. Else the ghost would trouble them. Then they cut wood for a pyre; the box is put on top of it and it is burnt. The body is poked with long poles in order to facilitate combustion. When it bursts and gas escapes they believe they hear the voice of the ghost. Men and women sit around the pyre and sing all the cradle songs of the clan which are contained in their legends. The remains are put into a small box and placed on trees. Cotton-wood trees are often selected for this purpose. The body of the shaman is also burnt.

Some time after the burial the son or nephew of the deceased erects a column in his memory (*ptsān*). As the meaning of such columns is not yet clear by any means, I asked 'Chief Mountain' to describe to me the festivals which he gave after the death of his father, who was a Gyispawaduwᴇ'da. His father had a squid for his protector (*nᴇqnô'k·*). After the death of his father he invited all the people to his house. During the festival the ground opened and a huge rock which was covered with kelp came out. This was made of wood and bark. A cave was under the rock and a large squid came out of it. It was made of cedar bark and its arms were set with hooks which caught the blankets of the audience and tore them. The song of the squid which was sung by the women sitting on three platforms in the rear of the house is as follows:—

|: *K·ag·aba'qskᴇ laqha' hâyâ'i* :|
|: It shakes the heaven hâyâ'i :|

Ntl k·akystl k·â'd'īkystl wī naqnô'k· lō gyigya'dᴇtl ts'ā'g·atl aks
For the first time comes great supernatural being in living inside of water
dᴇm în lîsā'yîltl am gyigya't.
to look at the people.

After the squid and the rock had disappeared a man wearing the sun mask appeared in the door, and when the people began to sing his song a movable sun which was attached to the mask began to turn. The sun belongs to the GyispawaduwE'da; the squid reminds the people that one of his father's ancestors when hunting squids at ebb tide was captured by a huge animal. His friends tried to liberate him, but were unable to do so. When the water began to rise they pulled a bag of sea-lion guts over his head, hoping that the air in it might enable him to survive, but when they looked for him at the next tide they found him dead.

After the festival 'Chief Mountain' erected the memorial column. It represented, from below upwards, first four men called Lōayō'k·s, or the commanders. These are a crest of the GyispawaduwE'da. Tradition says that one night some men for some purpose dug a hole behind a house near a grave-tree. They saw an open place in the woods, a fire in the middle, and ghosts were dancing around it wearing head-dresses. They were sitting there as though they were in a house, but the men saw only a pole where the door of this house would have been. Four men called Lōayō'k·s were standing at the door, and called to them *nagwī't!* (To this side!) Since that time the GyispawaduwE'da have used these figures.

On top of the four men was the sea-bear (*mEdī'ek Em akys*) with three fins on his back. Each fin had a human face at its base. His father had requested him to put the killer whale on the column, but he preferred to place the sea-bear on it because it is the highest crest of the GyispawaduwE'da. The tradition of the sea-bear tells how four brothers went down Skeena River and were taken to the bottom of the sea by Hagulâ'k·, a sea monster, over whose house they had anchored. His house had a number of platforms. Inside were the killer whales, Hagulâ'k·'s men. He had four kettles, called Lukewarm, Warm, Hot, Boiling, and a hat in shape of a sea monster, with a number of rings on top. The name of his house was Helahāi'dEk· (near the Haida country). He gave the brothers the right to use all these objects, and with them their songs, which are sung at all great ceremonies of the clan. The song of the house is as follows:—

I.e. My friend, walk close to the country of the Haida, the great Hagulâ'k·.

Hagulâ'k· also gave them two cradle songs, which are sung for children of the clan and also at funerals.

Atlgwa'sEm gunā't, atlgwā'sEm gunā't, atlgwā'sEm gunā't.
O real strong friend, O real strong friend, O real strong friend.

Maā'qtlu wīlwē'tk'tl tlgōkycamqk' tlguts'ālt tlguyō'hak'alā'q
Where he came from with his little black little face with his little club

yaq·abā't.
running down.

And the second one :—

Gunā'dēt, gunā'dēt, gunā'dēt, gunā'dēt.
O friend, O friend, O friend, O friend.

Wulnînnô'ôtlē, sEmtliā'n, hanqsā'nō, hangyā'ōksgō.
They are very white, the real elks, which he won gambling, which he found when they drifted down to him.

Marriage.—When a young man desires a girl for his wife he sends a certain amount of property (*hana'k·s*) to her parents for the purchase of the girl. If the suitor and the amount of property are acceptable, they send word to him stating that they accept his suit. Then the young man takes a number of slaves, who accompany him. They are called *lōdā'mEk·s-gut* (= always close to him). They arm themselves, and the young man embarks with them in a canoe and sails to the bride's house. As soon as her relatives see them coming, they arm themselves with clubs and stone hammers and rush down to the landing-place. They break the canoe and try to drive off the companions of the young man. They fight seriously, and sometimes one of the *lōdā'mEk·sgut* is killed. This foretells that the couple will never part. After the fight is over the bridegroom and his companions are carried into the bride's house. Then her friends strew eagle down, which is kept in a bag made of sea-lion's intestines, on the companions of the bridegroom, and the fighting ceases. Her father puts on his head-dress and dances while her friends sing. Then a feast is given, during which the young man pays the remainder of the purchase money. In the evening the girl's clan gives a considerable amount of property to the bridegroom (*lōgyinā'm*), which he distributes among his clan according to the amount which they have contributed to the purchase money. Her father and brothers give the groom a new canoe in place of the one which was broken in the morning. Then the bride is carried down to the canoe, and she departs with her husband to his village, where they live.

If the groom belongs to the same village, the couple often stay with the girl's parents.

The winter ceremonial.—I did not see any part of the winter ceremonial of the Nîsk·a', but I received descriptions which, in the light of our knowledge of these ceremonies among the Kwakiutl, bring out sufficiently clearly their similarities. There are six secret societies among the Nîsk·a', which rank in the following order: the SEmhalai't, Mēitla', LōtlE'm, Ōlala', Nanēstā't, Hōnana'tl, the last being the highest. The SEmhalai't is really not confined to the winter ceremonial, but is obtained when a person obtains the first guardian spirit of his clan and performs the ceremony belonging to this event. The tradition of the origin of these ceremonies is the same as that found among the Tsimshian, to which I alluded in the Fifth Report of the Committee, p. 853 (see the full legend in 'Zeitschrift für Ethnologie,' 1888). The version of the legend which I obtained from the Nîsk·a' localises the events at Bellabella, and it is added that the ceremonies were obtained first by the Gyitqā'tla (a Tsimshian tribe located on the islands south-west of Skeena River) from the Bellabella, and later on by the Nîsk·a′ from the Gyîtqā′tla. This is corroborated by linguistic evidence. All the names of these societies, with the exception of the first, are of Kwakiutl origin. [Mēitla′=teasing; LōtlE′m, Kwakiutl Nō′ntlEm=foolish; Ōlala′, name of a Kwakiutl ceremony; Nānestā′t, Kwakiutl, Nōntsîstā′latl, dance of Nō′ntsîsta; Hōnana′tl, dance of (??). The call of the Ōlala′, *hāp*, is also a Kwakiutl word designating eating.] The original tradition mentions three societies only—the second, third, fourth. This shows that the first is not a secret society, properly speaking, and that the fifth and sixth are later introductions. The Nîsk·a′ state that with the ceremonies came the use of large whistles. The Kwakiutl of Fort Rupert state also that the use of large whistles and the custom of eating slaves and corpses and of biting pieces of flesh out of the arms of people came to them from the Hē′iltsuk. We must assume, therefore, that these ceremonies originated in the region of Milbank Sound. As the legends of these societies throw a clear light upon their practices, I will give the Nîsk·a′ tradition of the origin of the secret societies in full.

A Wutsda′ (Bellabella) named Sag·aitlā′bEn (a Nîsk·a′ name) went hunting. He saw a bear, which he pursued. He shot it several times, but was unable to kill it. Finally the bear reached a steep cliff which opened and let him in. As soon as he entered he heard the voices of the Ōlala′ calling '*hāp*,' and he fainted. Then his soul was taken into the house. In the rear of the house he saw a large room partitioned off. The partition was hung with red cedar-bark. It was the secret room of the Ōlala′ (*ptâ′ôtl*). To the right of the door, on entering, was a secret room for the Mēitla′, and to the left of the door one for the LōtlE′m. The chief, who was sitting in the rear of the house, ordered a fire to be made, and spoke: 'Those here are the Mēitla′; they did not bring you here. Those are the LōtlE′m; they eat dogs; they did not bring you here. But these are the Ōlala′; they eat men; they brought you here. You shall imitate what they are doing.' He had a heavy ring of red cedar-bark around his neck, a ring of the same material on his head, and wore a bearskin. He said: 'You must use the same ornaments when you return to your people.' He took a whistle out of his own mouth and gave it to Sag·aitlā′bEn. He gave him his small neck-ring of cedar-bark, which instilled into him the desire of devouring men (therefore it is called *k·′âtsq* EM *lōH*, cedar-bark throat), and he gave him large cedar-bark rings and a small bearskin, which enabled him to fly. He told him: 'You shall kill men, you shall eat them, and carry them to my house.' Then he opened the door. The singers sang and beat time, and Sag·aitlā′bEn flew away from town to town over the whole world, crying '*hāp*' all the time. He went from the country of the Wutsda to Skeena River and to Nass River. Sometimes he was seen sitting on high cliffs. He killed and devoured people whom he found in the woods.

After three years he was seen near the village of the Gyit′amā′t. They attempted to catch him. They killed dogs and threw them into a hole, and a number of shamans hid under a canoe near by. Soon he was heard to approach. He alighted on the top of a dry cedar. He lay there on his stomach, and the point of the tree was seen to penetrate his body and to pierce it. But it did not kill him. When he saw the dogs he flew down, and, after having eaten, the shamans rushed up to him, caught him, and took him up to the house. They tried to cure him, and the people sang Ōlala′ songs, all of which have a five-part rhythm (♩ ♪ ♩). He tried to fly again, but was unable to get out of the house. Finally he was tamed and became a man. Then the Gyit′amā′t took him back to his home and received in return many slaves, coppers, and canoes.

The ceremonies take place in the month *Lôkys Em gunä′qk* (cold month, or December).

The LōtlE′m dance in a two-part rhythm: their call is a sharp *h, h*; their movements sudden jerks of the forearms, first the left moving up to the shoulder, while the right moves down, then *vice versâ*.

The Mēitla′ dance in a three-part rhythm. The last two dances correspond to the Nōntsistā′latl of the Kwakiutl. When the members of these societies are in a state of ecstasy, they throw fire around and knock to pieces canoes, houses, and anything they can lay their hands on.

The insignia of the societies are made of cedar-bark dyed red in a decoction of alder-bark. For each repetition of the ceremony a new ring is added to the head ornament of the dancer. Those of the LōtlE′m and Ōlala′ consist therefore of rings placed one on top of the other, while the Mēitla′ receives first a red ring, the second time a white ring, and so on alternating. His rings are twisted together.

There are only a limited number of places in the societies, and a new member can be admitted only when he inherits the place of a deceased member, or if a member transfers his place to him. If such a transfer is to take place, the consent of the chiefs of the clans must first be obtained. Then one evening the chiefs during a feast surround the youth and act as though they had caught the spirit of the society in their hands and throw it upon the novice. If he is to be a LōtlE′m, a noise: *hôñ, hôñ*, is heard on the roof of the house, and the youth faints. The LōtlE′m (or the members of the society in which he is to be initiated) are called to investigate why the youth fainted. They enter singing, their heads covered with down. They place him on an elk-skin, carry him around the fire, then they throw the youth upward and show the people that he is lost. After some time, when the novice is expected back, the people assemble in the house, and all the members of the nobility try to bring him back by the help of their spirits. In order to do this they dance with the head ornaments of their clans, their rattles, dancing blankets, aprons and leggings, or they use the head ornament representing two bears' ears, which is made of bearskin set with woman's hair, which is dyed red: this ornament is used by all clans; or they wear masks representing their guardian spirits (*nEqnô′k·*). As an example of these I will describe the spirit of sleep (*wôq*) which belongs to the GyispawaduwE′da. The owner of this spirit appears sleeping, his face covered with a mask, the eyes of which are shut. Then a chief steps up and tries to awake him by hauling the drowsiness out of him with both his hands. Then the eyes of the mask are opened, and roll while the man who wears the mask rises. The chief who took the drowsiness out of him asks if he shall try to put the people to sleep, and on being asked to do so he throws his hands open. The *nEqnô′k·* is supposed to enter the people, and all close their eyes. After some time he gathers the drowsiness again, and they awake and sing:—

| :*Aiwôtlwôqkuā′*, *aiwôtlwôgkō′* : |
Oh! how sleepy we are. Oh! how sleepy we are.

Adē gugō'ēt nētl gyamk' atl ts'ᴇmlaqha' ya tla gyîʜ tqaldū'utl dᴇm wôq
Whenever strikes me the heat of heaven ya! again comes (fut.) sleep
k·a's nēkc ᴇm wôq, kua!
to the husband of sleep, kua!

|: *Aiwôtlwôqkuā',* *aiwôtlwôqkō'* :|
Oh! how sleepy we are. Oh! how sleepy we are.

In this manner the spirit of sleep proves his presence and is asked to try to bring back the novice.

One *nᴇqnô'k·* after the other tries to bring him back. If the novice does not return by midnight of the first night, the ceremony is interrupted and continued the following night. On one occasion a member of the Lōtlᴇ'm was the last to try. He took his *nᴇqnô'k·*, a small carved human image, held it up, and asked it to bring back the novice. Then he poured a spoonful of grease into the fire and threw the carving after it. At once the whistles of the novice were heard on the roof. All the Lōtlᴇ'm rushed out of the house, but soon they returned, saying that they had seen him, but lost him again. They cried, '*ēh!*' (drawn out very long). Then all the people left the house. After the novice is lost in this manner he is expected back on the following day. Early in the morning a killer-whale or some other animal is seen on the river carrying the novice on his back. He is crying *mâ, mâ, mâ, mâ!* all the time, and the people go to see him. The Lōtlᴇ'm take a canoe and paddle, singing, towards the novice. When they have almost reached him one of their number, who stays ashore and wears a bearskin, drives all the people into the houses. The Lōtlᴇ'm take the novice into their canoe and destroy the whale float which carries him, and which is manipulated by means of ropes. Then he runs up and down the street like one wild, and the Ōlala' follow him and bite any of the profane who dare to leave the house. The novice catches a dog, tears it to pieces, and eats it going from house to house. When returning he is naked. Then they enter his house, which becomes tabooed. A rope hung with red cedar-bark is stretched from the door of the house to a pole erected on the beach, preventing the people from passing in front of the house and compelling them to go behind. A large ring of cedar-bark is fastened to the pole in front of the house. These remain on the house for a day after the return of the novice. On the following day four men put on bearskins and place rings of red cedar-bark on their heads. Thus attired they go from house to house inviting the people to see the dance of the novice and to learn his songs. When the people have assembled, the uncle of the novice throws blankets on the ground, on which the novice dances. Then his uncle pays the chiefs who tried to bring him back, and distributes blankets among the other people also. He gives a feast consisting of two kinds of berries, each mixed with grease. Chiefs are given large spoons filled with grease. Their people help them to empty the contents, as they must not leave any of the food that they receive. After the ceremony the novice is called *tlaamgya't* (a perfect man).

The man who wants to become a member of the Ōlala' must have been a *halai't* (shaman) first.

The following description of the initiation of an Ōlala' was given by a man who had gone through the ceremony himself, but who is a Christian now. It is a question to my mind if the ceremonies at the grave about which he told me were actually performed, or if he reflected only the dread in which the Ōlala' were held.

During a festival when he was to be initiated his friends pretended to begin a quarrel. They drew knives and pretended to kill him. They let him disappear and cut off the head of a dummy, which was skilfully introduced. Then they laid the body down, covered it, and the women began to mourn and to wail. His relatives gave a feast, distributed blankets, slaves, canoes, and coppers, and burnt the body. In short, they held a regular funeral.

After his disappearance he resorted to a grave. He took the body out of the grave and wrapped a blanket about himself and the body. Thus he lay with the corpse for a whole night. The other Ōlala′ watched him from a distance. In the morning he put the body back into the grave. He continued to do so for some time in order to acquire courage. All this time, and for a whole year, he was not seen by any member of the tribe except by the Ōlala′.

A year after his disappearance his nephew invited all the tribes to bring him back. This was done in the same manner as described above in the case of initiation of the LōtlE′m. Finally his whistles were heard, and he appeared on the roof of the house crying *ā lalalalala!* He disappeared again, and in the following night after prolonged dances he was seen on the hills dancing in a fire, which he had built in such a manner that when he danced behind it it looked from the village as though he was standing right in it. The following day he appeared carried by his totem animal.

The GyispawaduwE′da are brought back by a killer-whale, as described above; the Laqkyebō′ by a bear; the Laqskī′yek appear on the back of an eagle which rises from underground; the K·anha′da on the back of a frog. Sometimes the novice appears on a point of land some distance from the village carrying a corpse in his arms. Then he is said to walk over the surface of the water and to come ashore in front of the village. This is accomplished by means of a raft which is covered with planks, and burdened so that it floats a short distance under the surface of the water. It is pulled by means of a rope by some of the other Ōlala′ while the novice is dancing on it, so that the impression is conveyed that he has approached on the surface of the water. When he reaches the village he eats of the body which he is carrying, and one or other of the chiefs kills a slave and throws the body to the Ōlala′, who devour it. It is said that before eating human flesh the Ōlala′ always use emetics, and that afterwards they tickle their throats with feathers to ensure vomiting.

In festivals which take place during the dancing season the Ōlala′ receives his share first, and nobody is allowed to eat until he has begun to eat. He has his own dish and spoon, which are wound round with bark. Those who have been Ōlala′ formerly are his servants and bring him food. When he hears the word *lō′lEk* (ghost) he gets excited and begins to bite again. After he ceases to bite and to devour men a heavy ring of red cedar-bark is placed around his neck, and he is led slowly round the fire. The ceremony is called 'making him heavy' (*sEp′a′lyîq*), and serves to prevent his flying away and getting excited again. He must stay in his room for a whole year after his initiation. After biting he must chew the bark of 'devil's club' (*wôō′mst*), which acts as a purgative.[1]

In olden times the appearance of the artificial totem animal, or of the guardian spirit, which was described above, was considered a matter of

[1] See also Fifth Report, p. 853.

great importance, and any failure which would disclose the deception to the uninitiated was considered a great misfortune, which was atoned only by the death of those involved in the disclosure. One striking instance of an event of this kind which took place among the Hēiltsuk· was reported to me. Three brothers invited all the tribes, among them the Tsimshian, to a festival. The eldest was to return from a visit to the bottom of the sea. When the visitors landed they had to wait on the beach for his return. A rock was seen to emerge at some distance from the shore. It opened and the young man stepped out and danced, adorned with his headdress. Then he stepped back into the rock, which disappeared again in the waters. The rock was made of wood and covered with kelp. Its movements were regulated by means of ropes running to the woods where a number of men were hidden, who operated them. After the rock had emerged twice the ropes became entangled, and they were unable to make it emerge for the third time. The man who was hidden in the rock was drowned. The family of the man who was lost in this manner concealed their grief, and his brothers pretended that he had stayed with the spirit residing at the bottom of the sea. They went through the whole festival. After the guests had departed all the surviving members of the family tied themselves to a long rope, sang the cradle song of their family, and precipitated themselves from a cliff into the sea.

Shamanism.—In reply to my questions regarding the acquisition of supernatural helpers and the powers of the shaman (*halai't*), 'Chief Mountain,' who is nowadays a regular attendant at church, gave me the following account of his own experience. Only a man whose father was a shaman can become a shaman. When he himself was a youth the supernatural beings (*nEqnō'k·*) were pursuing him all the time. One day a beautiful girl appeared to him and he fainted. She taught him her song which enabled him to make the olachen come in spring, and which is as follows :—

Lawē'tl wul haqhā'gwuqtl akys atl k·igyē'wutl.
Behold where meet the waters on the beach.

Gyîtwulgyigyā'mk' wulōd'ātl k·ât cäky.
(People of warm place) where is heart olachen.

I.e. Behold where the tides meet at Gyîtwulgyigyā'mk' are many olachen.

She wanted to have intercourse with him. One night she took him through a fire, and since that time he was able to handle fire with impunity. When she left him he saw that she had an otter tail. Her name was *KcEmwa'tsq* (land-otter woman).

She is a *nEqnō'k·* of the Laqskī'yek clan. When he gave a festival he danced with the mask of this *nEqnō'k·*. He was covered with otter skins and wore claws of copper. He moved around the fire like an otter crying '*uhuiä'*. This ceremony is called the *SEmhalait.* Later on he saw four other supernatural beings, who had the shape of wild-looking men, who wore bearskins and crowns made of the claws of bears. They taught him to foresee sickness. At one time the Gyîtqadē'q disbelieved his power over fire. He asked them to build a large fire. He threw an iron hoop into it, moistened his hands, and covered his face, hair, and hands with eagle-down. Then he stepped barefooted over the glowing embers, took the redhot hoop, and carried it through the fire without burning his hands or his feet. He added that a few years ago he repeated this experiment, but as he failed and burnt his hands and feet he gave up his supernatural helper and became a Christian. He also added that many who pretend to be shamans have no supernatural helpers at all. They cannot cure or foresee disease. When he was called to cure disease the four supernatural men appeared to him and helped him. They told him to draw the breath of the supernatural beings out of the body of the patient. Other shamans suck the disease out of the body. They pointed out witches to him, and enabled him to see ghosts. A few years ago a number of shamans were dancing in a house. When he entered he saw a ghost dancing among them, and foretold at once the death of one of the shamans. Indeed, after a few hours one of them died. The shaman wears stone and bone amulets, and does not cut his hair. His appearance is the same as that of the Tlingit shaman.

Witchcraft is practised by people called *Haldā'wit.* They steal a portion of a corpse, which they place in a small, long, watertight box. A stick is placed across the middle of the box, and thin threads are tied to this stick. The piece of corpse is placed at the bottom of the box, and part of the clothing or hair of the person whom the *Haldā'wit* desire to bewitch is tied to thin strings. If it is in immediate contact with the body the person will die soon ; if it is hung a little higher he will be sick for a long time. If hair is put into the box he will die of headache ; if part of a moccasin, his foot will rot ; if saliva is used he will die of consumption. If the person is to die at once the *Haldā'wit* cuts the string from which the object is suspended, so that it drops right on to the corpse. This box has a cover, and is kept closely tied up. It is kept buried under the house or in the woods. After the *Haldā'wit* has killed his enemy he must go around the house in which the dead one is lying, following the course of the sun. After his enemy is buried he must lie down on the grave and crawl around it, again following the course of the sun, and attired in the skin of some animal. If they do not do this they must die. Therefore the Nîsk·a' watch if they see anyone performing this ceremony. Then they know that he is a *Haldā'wit,* and he is killed. He is not tied and exposed on the beach at the time of low water, as is done by the Tlingit. When a corpse is burnt the *Haldā'wit* tries to secure some of the charred remains and uses them for painting his face. This is supposed to secure good luck. The *Haldā'wit* sometimes assemble in the woods, particularly when dividing a body. Then they cover their faces with masks, so that a person who should happen to come near may not know them. If anyone should happen to see them they try to catch him and make him a *Haldā'wit* also. If he refuses to join them he is killed. Once a man by the name of K·'amwā'skyē was caught in this manner. He pretended to accept, and was given a mask. They made a song and sang while he danced

Yag·ahō'dē bā'lɛk·ē,
Wîlwulā'ns K·'amw·ā'skyē,

i.e. the ghosts run to the beach on account of the winds of K·'amw·ā'skyē. He emitted winds while he was dancing. He danced, hidden behind the trees. Then he turned his mask round so that it was on his occiput, and made good his escape. He reached his house, told what he had seen, and the *Haldā'wit* were killed.

The similarity between this method of witchcraft and the *ē'k·a* of the Kwakiutl (Sixth Report, p. 613) is striking.

As in olden times cremation was prevalent, they tried to secure bodies of persons who had died by accident before they were found by the friends of the deceased. They sold them among the other Haldā'wit. There are, however, many tales which mention the use of bodies for supernatural purposes as well as tree burial, such as is practised by the southern tribes. For this reason I suppose that the custom of cremating the body was borrowed recently from the Tlingit.

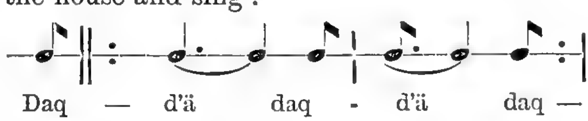
The following tale explains the ideas of the Nîsk·a' regarding the future life.

Once upon a time the GyispawaduwE'da killed Adinä'ky, the chief of the Laqkyebō.' There was a youth living in their town who happened to walk towards the graveyard chewing gum. There he saw a man approaching him, who wore a robe of marten skins. When he came nearer he saw that he was no other than the dead chief. The youth wished to run away, but the ghost overtook him and asked him for some of the gum he was chewing. The youth did not dare to hand it to him, and just pushed it out of his mouth. The ghost took it and turned back. The youth went home, and after he had told what had happened, he fell down and lay there like one dead. He had a perforated stone for an amulet, which he wore suspended from his neck. It was to insure him long life. His friends washed the body and put clean clothing upon him. Meanwhile the ghost carried his soul away. They followed a broad trail, and came to a river. He got tired of waiting, and yawned. Then he heard a noise in the town. A canoe came across to fetch him. He went aboard, and was taken to the chief's house. He was sick, and the chief ordered him to be laid down next to the fire, and called four shamans, who were to heal him. They tried to take his heart out of his body, but they were unsuccessful. They said, 'His breast is as hard as stone.' This was because he wore the amulet. Finally the chief said to the shamans, 'Let us give up our efforts. He is too powerful; we must send him back.' Then he was taken back to the canoe, and sent across the river. He returned the same way which he had come, and when he entered his house life was restored to the body.

The conception of the world is as follows :—

The earth is carried by a man named Am'ala' (smoke-hole). He lies on his back, and holds on his chest a spoon made of the horn of the mountain goat. It is filled with grease, and in it stands a pole on which the earth is resting. When he gets tired he lifts the pole, and the earth shakes. The pole, with the earth on it, is turning in the bowl of the spoon. The grease in it serves to make it turn easily. The earth is round. Sun, moon, and stars belong to the sky, and do not turn with the earth.

An eclipse of the sun indicates that a chief is to die. Then the whole tribe go out of the house and sing :—



The following games were described to me :—

1. Leha'l : the guessing game, in which a bone wrapped in cedar-bark is hidden in one hand. The player must guess in which hand the bone is hidden.

2. Qsan : guessing game played with a number of maple sticks marked with red or black rings, or totemic designs. Two of these sticks are

trumps. It is the object of the game to guess in which of the two bundles of sticks, which are wrapped in cedar-bark, the trump is hidden. Each player uses one trump only.

3. Matsqâ'n.—About thirty small maple sticks are divided into four or five lots of unequal numbers. After a first glance one of the players is blindfolded, the other changes the order of the lots, and the first player must guess how many sticks are now in each lot. When he guesses right in three, four, or five guesses out of ten—according to the agreement of the players—he has won.

4. Gōntl : a ball game. There are two goals, about 100 to 150 yards apart. Each is formed by two sticks, about ten feet apart. In the middle, between the goals, is a hole in which the ball is placed. The players carry hooked sticks. Two of them stand at the hole, the other players of each party, six or seven in number, a few steps behind them towards each goal. At a given signal both players try to strike the ball out of the hole. Then each party tries to drive it through the goal of the opposing party.

5. Tlēt! : a ball game. Four men stand in a square : each pair, standing in opposite corners, throw the ball one to the other, striking it with their hands. Those who continue longest have won.

6. Smênts.—A hoop is placed upright. The players throw at it with sticks or blunt lances, and must hit inside the hoop.

7. Matldä.'—A hoop, wound with cedar-bark and set with fringes, is hurled by one man. The players stand in a row, about five feet apart, each carrying a lance or stick. When the ring is flying past the row they try to hit it.

8. Halha'l : spinning top, made of the top of a hemlock tree. A cylinder, $3\frac{1}{2}$ in. in diameter and 3 in. high, is cut; a slit is made in one side and it is hollowed out. A pin, $2\frac{1}{2}$ in. long and $\frac{1}{4}$ in. thick, is inserted in the centre of the top. A small board with a wide hole, through which a string of skin or of bear-guts passes, is used for winding up the top. It is spun on the ice of the river. The board is held in the left, and stemmed against the foot. Then the string is pulled through the hole with the right. Several men begin spinning at a signal. The one whose top spins the longest wins.

V. LINGUISTICS.

I. NÎSK·A'.

The Nîsk·a' does not differ very much from the Tsimshian. There are certain regular changes of sounds—which, however, are not yet sufficiently clear to me, but some of which will become apparent by a glance at the comparative vocabulary—slight differences in grammar and in vocabulary. For this reason I confine myself to a very few remarks, leaving a full discussion of the collected material for a future opportunity.

The plural of noun and verb is formed in the same manner as in Tsimshian. Although the same words do not always follow the same rules, the classes are almost the same. The remarks regarding adjective and verb (Fifth Report, pp. 80, 83) hold good in Nîsk·a' also.

The system of numerals differs in so far as there is no separate class for ong objects.

Class	1 Counting	2 Flat Objects	3 Round and Long Objects, groups of forty	4 Men
1	ky'äk'	ky'äk'	ky'ē'ᴇl	ky'âl
2	t'ᴇpqā't	t'ᴇpqā't	ky'ē'lbᴇl	bag·adê'l
3	golā'nt	golā'nt	gul'ā'l	gulâ'n
4	tqālpq	tqālpq	tqālpq	tqalpqdâ'l
5	k'stēnc	k'stēnc	k'stēnc	k'stᴇnsâ'l
6	k·'â'ᴇlt	k·'â'ᴇlt	k·'â'ᴇlt	k·'âdᴇldâ'l
7	t'ᴇpqâ'ᴇlt	t'ᴇpqâ'ᴇlt	t'ᴇpqâ'ᴇlt	t'ᴇpqâdᴇdâ'l
8	k·andâ'ᴇlt	yuQdā'ᴇlt	yuQdā'ᴇlt	yuQdaᴇldâ'l
9	k'stᴇmâ'c	k'stᴇmâ'c	k'stᴇmâ'c	k'ctᴇmssâ'l
10	ky'ap	ky'ap	ʜpē'ᴇl	ʜpâl
11	ky'ap di ky'äk'	ky'ap di ky'äk'	ʜpē'ᴇl di ky'ē'ᴇl	ʜpâl di ky'âl
12	ky'ap dᴇ t'ᴇpqā't	ky'ap dᴇ t'ᴇpqā't	ky'ē'lbᴇl di ky'ē'ᴇl	ʜpâl di bag·adê'l
20	kyē'lbᴇl wul gya'p	ky'iyē'tk'	kyē'lbᴇl wul gya'p	} Class I.
30	gō'la wul gyap	gōla wul gyap	gō'la wul gyap	

Class	5 Canoes	6 Fathoms	7 Bundles of 10 Skins
1	k·amä'ᴇt	ky'ilgā'ʜ	gusky'ewa'
2	g·albä'ᴇltk's	ky'ēlbᴇlgā'ʜ	gyîlpwa'
3	gulā'altk's	gulalaô'n	—
4	tqālpqk's	tqalpqalô'n	—
5	k'stēnsk's	k'stēnsᴇlô'n	—
6	k·'âᴇltk's	k·'âᴇldᴇlô'n	—
7	t'ᴇpqâ'ᴇltk's	t'ᴇpqâᴇldᴇlô'n	—
8	yuQdâ'ᴇltk's	yuQdā'aldᴇlô'n	—
9	k'stᴇmâ'sk's	k'stᴇmâsᴇlô'n	—
10	ky'apk's	ʜpaō'ndē	—
11	ky'apk's di k·amä'ᴇt	ʜpaō'ndē di ky'ä'k'	—
12	ky'apk's di g·albä ᴇltk's	—	—
20	ky'iyē'tk's	—	—
30	ky'iyē'tk's di gyapk's	—	—

ORDINAL NUMBERS.

	Animate		Inanimate
The first	*Kysk·â'ôg·ôt*		*tsōgyē'ᴇlt*
The second	*tsogyē'lp'ᴇlt*		*tsogyē'lp'ᴇlt*
The third		*tsōgulā'alt*	
The fourth		*tsōtqālpq*	
The fifth		*tsōk'stēns*	
The sixth		*tsōk·'â'ᴇlt*	
The seventh		*tsōt'ᴇpqâ'ᴇlt*	
The eighth		*tsōyuQdā'ᴇlt*	
&c.			

The numeral adverbs agree with the words used for counting round objects.

PRONOUN.

Personal Pronoun.

I, *nēE.*	me, *lâ'E.*
thou, *nē'En.*	thee, *lâ'En.*
he, she, it (present), *net.*	him, her (present), *lâ'ôt.*
„ (absent), *nē'tgyê.*	„ „ (absent), *ĉsnē'tgye.*
we, *nōm.*	us, *lâ'Em.*
ye, *nE'cEm.*	ye, *lâ'sEm.*
they (present), *nē'det.*	them (present), *lâ'ôdEt.*
„ (absent), *nē'detgyê.*	„ (absent), *lâ'ôdEtgye.*

Possessive Pronoun.

There is only one form for presence and absence, except that the latter has the general suffix designating absence *-gya.* The past is formed by the perfect prefix *tl-*, the future by *dEm-*: The house that I had, *tlhwî'lbē*; my future wife, *dEmna'kysē.*

my father, *nEguâ'EdēE.*	our father, *nEguâ'EdEm.*
thy father, *nEguâ'EdEn.*	your father, *nEguâ'EtsEm.*
his father, *nEguâ'Ett.*	their father, *nEguâ'Edet.*

THE VERB.

Intransitive Verb.

The forms of the verb are also simpler than they are in Tsimshian.

I am sick, *sī'êpk'neE.*	we are sick, *sîpsī'êpk'nōEm.*
thou art sick, *sī'êpk'nēn.*	ye are sick, *sîpsî'êpk'nēsEm.*
he is sick, *sī'êpk.*	they are sick, *sîpsī'êpk'.*

The perfect is formed by the temporal prefix *tlE-*, the future by *dEm-*.

Interrogative.

am I sick? *sī'êpgunēia.*	are we sick? *sîpsī'êpgunōEma.*
art thou sick? *sī'êpgEnēna.*	are ye sick? *sîpsī'êpgunēna* (?).
is he sick? *sī'êpgua.*	are they sick? *sîpsī'êpgua.*

Negative.

I am not sick, *nîyî(di) sī'êpguē.*	we are not sick, *nîyî(di) sîpsī'êpguEm.*
thou art not sick, *nîyî(di) sī'êpguēn.*	ye are not sick, *nîyî(di) sîpsī'êpk'sEm.*
he is not sick, *nîyî(di) sī'epguēt.*	they are not sick, *nîyî(di) sîpsī'êpk'tet.*

Transitive Verb.

The transitive verb shows also small differences from the Tsimshian verb. I give the forms of the verb to kill—singular *dzak'*, plural *yadzı*—for the imperfect, which was not given in the description of the Tsimshian. The present tense is analogous to that of the Tsimshian.

—	I	thou	he	we	ye	they
me	—	dzak'dEnēE	dzak'dEtnēE	—	dzak'dEsEmnēE	dzak'dētnēE
thee	dzak'dēnē'n	—	dzak'dEtnē'n	dzak'dEmnē'n	—	dzak'dētnē'n
him	dzak'dē'E	dza'k'dEn	dza'k'dEt	dza'k'dEEm	dza'k'dEsEm	dzak'dē't
us	—	ya'dzinnōm	yadzitnōm	—	yadzEsEmnōEm	yadzdētnō'Em
ye	yadzinē'sEm	—	yadzitnē'sEm	yadzEmnē'sEm	—	yadzdētnē'sEm
them	ya'dzi	yadzEn(nē'EdEt)	ya'dzEt	ya'dzEm	ya'dzEsEm-(nē'EdEt)	ya'dzdēt

The interrogative is formed by the suffix *-a.*

The imperative of the transitive verb is expressed by the second person of the indicative, that of the transitive verb by the suffix *-tl.*

eat, *yō'uqgun.*	eat it, *gyîptl.*

I have obtained a considerable number of prefixes and suffixes, a list of which is given here.

Prefixes.

an-	abstract nouns.
aq-	without.
agwī-	outside.
atlda-	in darkness.
asē-	from middle to side of house.
baq-	uphill.
da-	with.
dE-	to cause.
dEp-	down.
gwīH-	*nomen actoris.*
gulî'kys-	backward, one's self.
gun-	to cause an action.
g'utgō-	around.
g'utl-	about.
gus-	blanket.
gyici-	down river.
gyini-	left behind.
g·an-	state of.
g·ani-	for good.
g·'ap-	entirely, certainly, by necessity.
g·ali-	up river.
g·al-	too much.
hadîH-	along, lengthwise.
ha-	instrument.
hagun-	near by, toward speaker.
haspa-	inverted.
hagul-	slowly.
hîs-	to appear to be.
hī-	beginning of.
i-	with reduplication, action done during motion.
kcE-	fluid.
kcEm-	woman.
kci-	out of.
ktlē-	all over.
ky'êdō-	sideways.
ky'aq-	for a little while.
kys-	extreme (plural *da-*).
k·'a-	more, comparative.
k·'aldîH-	in woods.
k·alHsi-	through.
k·ani-	without interruption.
kcEq-	only, without instrument.
qpī-	partly.
q-	accident happening.
qs-	resembling, sound of, called.
qpî'lyîm-	forward.
qtlEm-	around an obstacle.
qtlna-	bent forward.
q-	to eat.
qtsE-	across middle.
lāq-	to and fro.
lîgy'ē'q-	part of.
libElt-	against.
lEg·Em-	into, from top.
lEg·'ul-	for good.
lē-	on.
lō-	in.
luktl-	under.
lōsa-	in front of.
lEks-	strange.
lēg·an-	over.
man-	upward.
mEsEm-	separate.
mē-	like.
na-	to break, come to.
nōom-	to desire.
pElEm-	to attempt.
spī-	out of water towards land.
sE-	to make something.
sîl-	to accompany.
sk·a-	obstructive, sideways.
staQ-	along.
ca-	off.
t'am-	from side of house to middle.
tk·al-	against.
ts'ā-	suddenly.
tk'ō-	around.
tqa-	altogether.
tqas-	long thing.
ts'Em-	in.
ts'E'lEm-	into (from the side).
tEkc-, *ukc-*	out of water.
ts'En-	left behind.
ts'Eg·Em-	landward.
wītl-	away.
wud'En-	away.
yag·a-	down to beach, out of woods.
yEg·Es-	down.
tlEm-	stopping a motion.

Suffixes.

-ma	dubitative.
-k·at	quotative.
-an	to make.

A comparatively full grammar of the Tsimshian has recently been published by Count Dr. A. von der Schulenburg.

2. THE TS'ETS'Ā'UT.

Unfortunately my informant Levi, the only one from whom I was able to obtain grammatical information, was exceedingly difficult to manage, and I did not succeed in making him understand that I desired to have Ts'Ets'ā ut sentences and accurate translations. For this reason my material is very unsatisfactory, and does not permit an accurate description of the structure of the language. Besides this the Tinneh phonetics are difficult, and Levi could not be induced to speak slowly, which circumstance made the work still more difficult. I give on the following pages a few remarks on the grammar, which will show what position the dialect takes among other Tinneh dialects.

THE NOUN.

The noun has no gender. I did not find any indication of the existence of separate forms for dual and plural, although these occur in Loucheux, Hare, and Chippewayan. Cases do not exist.

Compound nouns are of frequent occurrence. They are formed by means of juxtaposition. Possession is often expressed by this means.

dirt, *kwutl'ê fä'* (=sand-mud).
bear meat, *fu tsqa.*
female salmon, *tlEbê' ēk!ō'.*
hoof of goat, *abva' aba'.*
top of tree, *ts'ū tlā.*

NUMERALS.

1. êtliē'ê.
2. tlē'id'ê.
3. tqādēd'ê.
4. at'ōnêē'.
5. êtl'äda'.
6. êtltāts'ê.
7. tlēid'êthatlē'ê.
8. tqātqatliē'ê.
9 êtlitlā'Hōdunêē'ê, êtliad'unêē'ê.
10. tlōky'ada'.
11. tlōky'ada' êtliē'ê.
20. tlēid'ê tlōky'adê'.
30. tqādê tlōky'adê'.

THE PRONOUN.

Personal Pronoun.

I, *sqE'nê.*
thou, *ninê'.*
he, ?
we, *daQô'ô.*
ye, *daQô'nê.*
they, ?

Possessive Pronoun.

my, *ēs.*
thy, *nē.*
his, *ma.*
our, *dā.*
your, *dā.*
their, *ma.*

Before words beginning with *k*, *ēs* becomes *îQ*. For instance:

my house, *îQ khō.*

THE VERB.

The verb is exceedingly difficult to understand, and the meagre material which I obtained from Levi is insufficient for a clear understanding of the subject. There are a number of classes of verbs, as will be seen by the following examples:—

to sing (*Petitot*, 2nd class).

I sing, *îsdji'.*
thou singest, *îndji'.*
he sings, *mdji'.*
we sing, *daō'dji.*
ye sing, *daadji'.*
they sing, ?

to be ashamed (*Petitot*, 5th class).

I am ashamed, *ōca'.*
thou art ashamed, *ōnHa'.*
he is ashamed, *ōHa'(ka).*
we are ashamed, *da'ōHa.*
ye are ashamed, *da'aHa.*
they are ashamed, ?

to be afraid.

I am afraid, *nēsdjē'.*
thou art afraid, *nēndjē'.*
he is afraid, *nēdjē'.*
we are afraid, *dā'nidjē.*
ye are afraid, *danadjē.*
they are afraid, *danêdjē'.*

to be cold.

I am cold, *sēistlu'*.
thou art cold, *sintlu'*.
he is cold, *sätlo'*.

we two are cold, *HEē'itl*.
we are cold, *dā'sitlo*.
ye are cold, *Qaatlō'*.
they are cold, *HiHitlō'*.

to speak.

I speak, *QuEsdä'*.
thou speakest, *Qundä'*.
he speaks, *Quadä'*.

we speak, *daQō'idä*.
ye speak, *daQoadä'*.
they speak, *daQoadä'*.

The future is formed by the vowel *ū*.

I skin it, *dîstccc'*.
I eat, *îstsqê'*.
I tear it, *nē'stsê*.

I shall skin it, *dustccê'*.
I am going to eat, *ūîstsqê*
I shall tear it, *nū'stsê*.

The interrogative is formed by the suffix *-ya*:

art thou cold? *sindlō'ya*.
has he got a wife? *nts'ayā'ya*.

The negative is formed by the suffix *-dEbê'*:

I am not sick, *ēsaai'dEbê*.
I have no dog, *îstlē'dEbê*.

There are numerous irregular verbs, particularly verbs of motion, but my notes on this subject are very fragmentary:

to run.

I am running, *dē'istl'a*.
thou art running, *dēintl'a'*.
he is running, *datl'a'*.

we are running, *tldEnē'idê*.
ye are running, *tldinō'odê*.
they are running, *tldî'nadê*.

to swim.

I am swimming, *gyîna'sbê'*.
thou art swimming, *gyîna'mbê*.
he is swimming, *gyînabê'*.

we are swimming, *k'ā'eō*.
ye are swimming, *gyînaō*.
they are swimming, { *kanā'ô*. / *gy'ina'ô*. }

I found only a few dual forms, but there no doubt that many more exist.

I am sitting, *sēsda*.
we two are sitting, *sikyê'*.
man sitting, *dēidz'a'*.

run up, sing. *sēitl'a*.
run up, dual, *sē'a*.
run up, plural, *sēdê*.

The prefixed pronouns of the various tenses differ in the same manner as in other dialects, but I have not been able, so far, to systematise the fragmentary material at my disposal.

The preceding remarks show, however, that the dialect of the Ts'Ets'ā'ut is more closely affiliated to the Chippewayan and Sarcee than to the Chilcotin and Carrier dialects.

The following pages contain a comparative vocabulary of two dialects of the Tsimshian, the Tsimshian proper and the Nîsk·a', and of three Tinneh dialects: the Tatltan (Tahltan), Ts'Ets'ā'ut, and the TkulHiyogoā'ikc. The last of these is extinct. The tribe inhabited the Upper Willopah River, in the State of Washington, and is, therefore, the most northern of the great number of Tinneh tribes which are scattered along the Pacific coast. The dialect is, for this reason, particularly interesting. I am indebted to Major J. W. Powell, Director of the U.S. Bureau of Ethnology, for permission to publish the vocabulary of this tribe which was collected by George Gibbs in February 1856, and which is in the Library of the Bureau of Ethnology in Washington, D.C. Gibbs calls the tribe erroneously O'whil-lapsh (Quila'pc), this being the name of the Chinook tribe of the Lower Willopah River. Their name in the Chinook language is TkulHiyogoā'ikc, which agrees with Anderson's name Kwal-whee-o-qua: their dialect seems to be almost identical with that of the Klatskanai. I obtained a few words on my last journey from an old Chinook woman, which I add to Gibbs's list. He introduces his vocabulary with the following remarks:—

G. Gibbs, Willopah, *February* 1856.

From an Indian at S. G. Fords.

'Of the Willopah tribe formerly inhabiting that river and the head waters of the 'Chihalis, there are, I believe, but two families left; from a man belonging to them 'I obtained the following:—

'He called his people O'whil-lapsh, the termination of which I should, however, 'judge to be of Chihalis origin. Their territory he called Whilâp-a-hai-you. The 'vocabulary was taken down in some haste, and, besides being incomplete, is not 'always altogether correct. Enough, however, is given to afford evidence of its character.'

'Mr. Anderson says: "The Kwal-whee-o-qua seem, from what I can learn, to have '"occupied the Willopah River and its tributaries towards the head of the Chihalis, '"and to have interlocked with the tribe who inhabited the country bordering on the '"Elokamin River. Their habits of life seem to have been very similar to those of the '"Klatskanai—the chase and an interior life for part of the year—resorting to the main '"rivers at certain periods to secure a supply of salmon."'

The Tatltan vocabulary is reprinted from Dr. G. M. Dawson's report on that tribe ('Annual Report of the Geological Survey of Canada,' 1887, p. 191, B. ff.). The words in parenthesis in the Ts'Ets'ā'ut vocabulary were obtained from Timothy, and differed from those obtained from Levi. The latter said in explanation that Timothy's father had come from Laq'uyî'p (Naqkyina), and that for this reason Timothy spoke slightly differently. The two vocabularies show clearly that Tatltan and Ts'Ets'ā'ut are closely affiliated, but that certain regular changes of sounds occur, particularly *ts* in Tatltan becomes *f* in Ts'Ets'ā'ut, and *t* is often replaced by *tq* or *tr*. Other changes are not so certain, and may be based on differences in perception and method of recording. It would seem that the TkulHiyogoā'ikc resembles the northern dialects more than those of the interior of British Columbia, but I am not sufficiently familiar with the latter to satisfactorily judge on this point. In both the Tatltan and TkulHiyogoā'ikc vocabularies I have retained the original spelling.

English	Tsimshian	Nîsk·a'	Tatltan (Dawson)	Ts'Ets'ā'ut	TkulHiyogoā'ikc (Gibbs)
Man	iō'ot	gyat	den'-e	tranê' (trä)	tee-e't-sun
Woman	hanā'aq	hanak·	e-ga-tēn'	aqadē'	whoo-ah-te
Boy	wōmtlk	—	etō-nē'	îHkyî'e	ske-e'h
Girl	—	—	'te'-da	t!äE	—
Infant	gyinē'es	—	—	dwunē' (dōnē')	—
Father	nEguā'at	nEguā't	ē-te'-uh	täE	(*my-*) s-tah
Mother	nâ'E	noq	e-tlī	ê-dlē'E, idê', nā	„ s'ehnah-na
Husband	naks	—	(*my-*) es-kuh-lē'-na	ts'aya'	„ s'kud *or* s'kuda
Wife	naks	—	„ es-tsi-yā-na	kadl'aē'	„ s'aht
Son	—	—	„ es-tshī-me	tcū'u	au-kwa
Daughter	—	—	„ es-too'-eh	tQū	—
Elder brother	wegy	—	„ es-tī-uh	Qudē'E	(*my-*) s'ohn-a-re'p
Younger brother	tlEmktē'	—	„ es-tshīt'-le	êtccē'ê	„ s'keh-te
Elder sister	—	—	e-tā'-ta	sā	—
Younger sister	—	—	(*my-*) es-tē'juh	êdä E	„ s'teh-tse
Head	tEmg·ā'us	t'Emg·ê'c	„ es-'tsī	atsē'	„ s'nehn
Hair	g·ā'us	g·êc	„ es-tsī-gā'	atsēqa'	„ se'ra'ch
Face	ts'al	ts'al	„ es-nē	tränē	—
Forehead	wâpq	ōpq	„ es-tsē'-ga	etsedā'	„ s'ta'h-ke
Ear	mō	muQ	„ es-thēs'-botl	dzē'E	—
Eye	wul'E'l	ts'al	„ es-tā'	adā' (trāE)	„ s'nah-rhe'
Nose	dz'aq	dz'ak·	„ es-tshī	etse'E	„ s'ehts
Mouth	kutl'ā'q	ts'Emā'k·	„ es-sāt'-a	asa'	„ s'tah
Tongue	dū'Ela	dē'liH	„ es-sā'	atsu'sa	„ soh
Teeth	ua'n	uä'n	„ es-gooh'	ê'Qō	„ se-roh
Beard	ēmq	iē'mk·	„ es-stane'-GUH	ā'Qa	„ stah-ra
Neck	t'Emlā'nē	t'Emlā'niH	„ es-kōs'	akwô	„ squus
Arm	—	t'Emk·ā'H	„ es-sī-tluh	agā'	„ ska'h-ne
Hand	an'ô'n	an'ô'n	„ es-sluh'	ā'tla	„ se-la'ch
Fingers	—	k·atsuwē'ênk·s	„ es-sluh' *or* slus-sē-guh	ā'tla ts'â	„ „
Thumb	mâs	mmâs	slus-tshō'	ā'tla tsqa	—
Little finger	—	sk·ē'niH	slus-tshed'-le	—	—

English	Tsimshian	Nîsk·a′	Tatltan (Dawson)	Ts'Ets'ā'ut	TkulHiyogoā'ikc (Gibbs)
Nails	tlEqs	tlak·s	(*my-*) is-lā-gun′-a	ā′tla k·anē′, atlgo′-na	(*my-*) s'chu′l-le
Body	—	ptlnāQ	„ es-hīa′	ê′Hiê	—
Chest	k·ā′yek·	k·'ētlk·	„ es-tshān	êdjuträ′ê (atrê′ya)	—
Belly	bEn	ban	„ es-bēt	êbê′	„ s·'chahn
Female breast	—	mà′dz'ìk·s	ma-tō′-ja	t'â	„ se′h-te
Leg	—	t'Emtlā′m	(*my-*) es-tsēn-a	asrä′e	—
Foot	sī	sa′-i	„ es-kuh′	êkya′E	„ skeh
Toes	—	k·atsuwē′Enk·s	„ es-kus-tshō′	êkyaE ts'â	„ skeh
Bone	sā′yup	—	„ es-tse^{n}′	atsrE′na	„ tsu′nn
Heart	k·â′ôt	g·â′ôt	„ es-tshēa′	êbvä′E	„ steh-ye
Blood	itlē′	itlä′ê	e-ted-luh	adi′la	too'tl
Village	k·alts'a′p	k·alts'a′p	kē-yē′	Hidaa′	—
Chief	sEm'â′gyît	sEm'â′gyît	tin-ti′-na	anEqa′	ks-ke′h
Warrior	—	wuldi′gyîtk'	e-ted′-etsha	—	(*enemy?*) wuts-e′h-ten
Friend	nEsē′bansk'	nEsē′b'Ensk'	es-tsīn-ē	—	—
House	hwālp	hwîlp	kī-mah′	khō	köte
Kettle	—	ndzam	'kōtl	k·'u′lê	cheh-he-hats-kus-see
Bow	haukta′k·	haQda′k'	des-ān	îtHe′	kl-toh-wa
Arrow	hāwā′l	hawî′l	'kah	k'a	—
Axe	dahE′rEs	dawī′s	tsī-tl	dzē′ra	tl'ke-räits'tl-tse′h-re
Knife	hatlEbī′êsk	hatlEbî′sk	pēsh	bê	tche-ro′h (*iron*)
Canoe	qsâ	māl	ma-lā′-te	nātla	tse′h (*generic*)
Moccasins	ts'â′ôqs	ts'ā′wîk·s	e-tshil-e-kēh′	tsĕk·ā′E	tl-na′ts-ee-äi
Pipe	aqpēyā′n	haqmiyä′n	—	k·âtHē′	stah-wootl
Tobacco	wundâ′	miyä′n	tsē-a-KH	k·â	suts-u′l-tus-see
Sky	laqha′	laqha′	ya-za	yad'a′	hook-kwäi-le′h-ne
Sun	gyā muk	tlôk·s	tshā	fa	hrah-tleh
Moon	gyā muk	tlôk·s	—	fa	hrah-tleh
Star	p'iā′ls	pElî′st	SUHM	srô	kah-lessie
Day	sa	mEsā′H	zeu-ēs	—	—
Daylight	—	—	yē-kā′	yakqa′	—
Night	hō′opEl	aqk'	ih-klē-guh	ētl'a′E	tca-a′hūte
Morning	k·antla′k·	hē′tluk	tshut-tshaw-tlunē′	tsētsâ′ôtlqu′na	ka′h-hum-ta
Evening	skī′yetlak·s	sē'l	hih-guh′	qudā′Hia	tcha-ahu-ta
Spring	—	guâ′yîm	tā-nē′	—	—
Summer	sōnt	sînt	klī-we-guh′	trā′nê	seh-nie
Autumn	ksō′ot	k'sît	tā-tla′	—	—
Winter	k'âtl	wul mā′dEm	ih-ha-yēh	Qū tsē′	kwuts'e′h
Wind	päsk	ba′ask'	it-tsī′	ēbvē′	tlt-se′h
Thunder	kalaplē′êm laqha′	tia′etk	it-ti-i-tshī′	ūnē′i	näi-ult-se-re′h
Lightning	ts'a′mti	ts'amtH	kun-ta-tsēl	unē da′	—
Rain	hwās	haiwî′s	tshā	tsaE	nar-reh-ä′ih
Snow	mā′dEm	mā′dEm	zus	Qô	yuchs
Fire	lak'	lak'	kŏn	kwô	kwunn
Water	aks	akys	tsoo	tQô	toh, tsnah-neh
Ice	dā′u	dā′u	ten^{n}	tqa	kwul-lo′h
Earth	dsā′atsEks	ts'ä′ts'îk·s	nēn	nêE	ne-e′h
Sea	laq mân	laqsē′ldê	ē-ētla	tQô tsqô	to-a′hr-ra
River	g·'ala aks	g·'aliakys	too-dēsă	tQô′ ga	toh
Lake	—	t'aq	mēn	mäE	chus-ka′h-ne
Valley	tlkut'ē′en	ts'Emt'e	tā-gōs′-ke	māgaQaqō′	tseh
Prairie	—	laq'amā′k's	'klo′-ga	dūditl'amê′	tseh
Mountain	sqanē′ist	sk·anî′st	his-tsho	tsE′nēE	sus-kut
Island	lEksd'a′	lîkysd'a	ta-ĕ-too-e	—	—
Stone, rock	lâp	la′ōp	tsē	tsha	sta′h-witl
Salt	mân	mô′ôn	ē-ētlă	—	—
Iron	t'ō′otsk	t'ōtsk'	pes-te-zīn′	—	tche-ro′h
Forest	—	spätk·ang·a′n	got-ĕ	—	—
Tree	k·an	g·an	tli-gē-gut′	ts'ô	s'chinn
Wood	—	lak'	tset-tsh-tsēlsh	pfô	t'kinn
Leaf	ia′nEs	ia′ns	e-tāne′	ā′traE	kutt
Bark	gyīmst (*shredded*)	mä′Es; gyî′m'-Est (*shredded*)	ed-lā	atlat'ō′u	s'kaih
Grass	kEyâ′qt	hap′E′sk'	klōăh	ā′traE	kluhw
Pine	—	amsgyînî′st	gā-za	tsEwäHä′	s'chunn
Flesh, meat	ca′mi·	smaH	e-tsēt′	atsqa′	che-chunn
Dog	has	os	klī	tlē	klehl
Bear	ôl	ôl	shush	fô	til-e-zun
Wolf	kyebō′	kyibō′	tshī-yō-ne	êqa′	ne-nah-ta-lie
Fox	—	nag·atsê′	nus-tsē′he	—	—
Deer	wan	wan	kīw-igana	qâ′ra	yun-a′hl-yil (*white-tailed deer*)
Beaver	sts'âl	ts'Emē′liH	tshā	tsaE	no-ne-yeeh

English	Tsimshian	Nîsk·a'	Tatltan (Dawson)	Ts'Ets'ā'ut	Tkulhiyogoā'ikc (Gibbs)
Rabbit	—	—	guh	k·aq	—
Fly	—	—	tsī-mēh	tlātlra'	—
Mosquito	gyī'ek	hiâ'sk	tsī	dzEsdzà'	—
Snake	matqalā'ltq	laElt	—	—	ke-ru'ss
Bird	ts'ō'wots	ts'ōts	tsī-mēh	—	na'ht-ke (*a winged thing !*)
Egg	—	tlgyîma't	ē-ga-zuh'	—	che-reh-zie
Feathers	lī	laq	tshōsh	ā'qa	ch'ohts-kwu
Wings	k·'āk·'ā'i	k·ak·'ā'ɪɪ	mī-ī-tsēne	mā't'a	ch-na'ht-keh
Goose	hā'aq	hak·	gān-jeh	dāwa'k·	—
Duck (Mallard)	mē'Ek	nEqnā'q	too'-deh	nEsna'q [7]	haat-hat (=Nsk·-wali)
Fish	luwE'lEm ts'Em aks	luwE'lEm ts'Em-akyc	klew'-eh	—	—
Salmon	hân	hân	klew'-eh	tlEmä'	(*spring salmon*) see-loh-kwa
Name	wā	wa	on-yeh	—	tcho-se'h
White	màks	ma'uks [1]	ta-'kād'-le	dak·'alä'	kl-kwe'e-yeh
Black	t'ō'otsk	t'ōtsk' [2]	ten-es-klā'-je	dE'nEstl'Ena	kluz-zun-ne
Red	mEsk	itlā'ētk' [3]	te-tsī-je	dEsdE'la	kl-che'h-ke
Blue	kuskua'sk	qsgusguâ'ôk's [4]	te-tlesh'-te	—	kluz-zun-ne
Yellow	mEtlē'itk	qslêtEg·'al-mâ'sk' [5]	tsīm-tlet	dEstsqa'wē	—
Green	mEtlē'itk	mEtla'tk [6]	tsīm-tlet	dEstsqa'wē	tch-zu'm-me
Great, large	wī	wī	e-tsho	ntsqa'	ō-ē'h
Small, little	tlgua	tlgua	ta-a-tsed'-le	utsā'E	hwe'hl-e
Strong	—	daqgyat	na-tō-yi	adE'ntsqa	nu-me'h
Old	wud'ā'gyat	wud'aqgyat	es-tshān	sā'na [8]	tsunn (*bad or worn*)
Young	copac	qa'cma's	es-kī-uh	dEguanaHä'	ahr-re-yie (*new*)
Good	ām	ām	e-tī'-uh	a'tawa	ne-zo'-a-nie
Bad	hada'q	had'a'q	tshā'-ta	tsa'at'ê	n'tsun-ne
Dead	ts'ak	nô	a-juh'	tEzā'ts'a	re'h-to-eh
Alive	dō'Els	dEdēls	te-tshī'	—	tah-ke-re'h-to-eh (*not dead*)
Cold	kua'tkō	gunä'qk'	hōs-tlī'	Qusg·'a's	kose-kwut-sie
Warm	gyā'muk	gyāmky	hos-sītl	Quskô'n	kl-ko'-ne
I	nE'riō	nē'E	shī-ni	tsqEnê'	shik
Thou	nE'rEn	nē'En	nīn-e	nenê'	nuk
He	nē'EdEt	net	a-yī-ge	—	—
We	nE'rEm	nōm	ta-hun'-e	taqo'n	nai'-yook
Ye	nE'rEcEm	nE'cEm	kla'-tse	taqona'	hon-ne'k
They	nē'EdEt	nē'dEt	—	—	—
This	—	tgōn	tī-te	—	che-ka'nn
That	—	tgōst	a-yī-ge	—	che-tu'k
All	tqani	tqanē'tk'st	sē-tse	daqō'ô (?)	a-wa'ht-hlo
Many	ha'ldE	hēld	oo-tla^n	its'ā'ada	klah-ne'
Who	gō	nā	ma-dai-e	māE	tsai-in
Far	d'ā	nak'	nī-sā-te	itīya	ne-za'ht-so-neh
Near	—	dēlpk'	hah'-ne	wuHī'ya	che-kehn-tis-tie
Here	yā'gua	tgōn	tīs-tsik	aHī'ya (?)	—
To-day	sēigya'wun	sagōn	too'-ga	adō'	tchut-seh-nie
Yesterday	gyets'ē'ip	ky'ā'ōts	kit-sō'-kuh	idzagia	kun-tahn
To-morrow	tsegyets'ē'-ip	t'atlak'	tsha-tshā'	tsatsā'	kl-ka'hn-te
Yes	ō	nêt	ēh	âE	kli-ne'h-ko (? *certainly*)
No	atlgE	nē	tī-wuh	dEbê' (dō'wê)	lak-ke
One	*See grammatical notes*		tlī-geh'	êtliêê'	kle-e'h
Two		„	tla-kēh	tlē'id'ê	na'ht-keh
Three		„	tā-tē'	tqādēd'ê'	tah-keh
Four		„	klen-teh'	at'ōnêê'	tun-cheh
Five		„	klo-dlāe'	êtl'ā·la'	la-aht-la
Six		„	na-slikē'	êtltäts'ê'	ks-la'h-neh
Seven		„	na-sla-kēh'	tlēid'êthatlē'ê	che-te'h-heh
Eight		„	na-stāe'	tqātqatlē'ê	che'h-na-wah
Nine		„	na-sten-teh'	êtliad'unêē'ê	kws'ta'h-heh
Ten		„	tso-snā'-ne	tlōky'ada'	kwin-eh-she-a ; klutch-ehl-tcho.
Twenty		„	ten-tlā-dih-teh'	tlēid'ê tlōky'adê'	nahtklitch-e'hl-tcho
To eat	yā'wîq	yō'ôqk'	etz-et-etz'	tsqa'	tsah-ne
To drink	aks	akys	etz-oo-tān-en-e	tQō Hinē'saê (*thou-*)	ts'nah-ne
To run	baq	baq	kīs-too-tshē-ane	tl'a	tehl-chul

[1] Snow colour. [2] Iron colour. [3] Blood colour. [4] Blue jay colour. [5] Colour of inside of crab. [6] Gall colour. [7] Loaned from Nîsk·a'. [8] Loaned from Tlingit.

English	Tsimshian	Nîsk·a′	Tatltan (Dawson)	Ts'ɛts'ā′ut	TkulHiyogoā′ikc (Gibbs)
To dance	halā′it	hala′it	en-dlē′	—	ne′h-tci′s-to
To sing	lī′emi	lī′mîH	en-tshīn	djê	stah-wheh-lum
To sleep	qstôq	wôk·	nes-tētl′	s—tHê	n'teh-la-to
To speak	a′lgyaq	a′lgyîq	hun-tēh	Qundê′	yah'tl-st-keh
To see	nē	gyê	nat-sī	êdē′n'ê	näh-ta-res-to
To love	sɛbā′n	—	na-cs-tlook′	dînHē′	—
To kill	ds'ak	dzak'	tsin-hia′	dēnɛHē′ya	noo-ne′k-la-rah
To sit	d'a	d'a	sīn-tuh′	sîndā′	ne′ht-sa-to
To stand	hā′yitk	hētk'	nun-zit′	nênsqê′	ne′k-luk-sto
To leave	dā′wult	k'stak·s	un-tlh′ (*to go*)	niqɛndō′sa (*in canoe*)	teh-a′s-to (*to go*)
To come	kâ′ɛdlɛks	ā′dɛkysk'	a-nēh′	aqunê′	neh-as-to
To walk	—	—	yes-shā′-dle	—	nah-ya
To work	—	—	ho-ya-estluh′	—	—
To steal	—	lē′luks	en-a-ī	ana′ē	—
To lie down	nâg	gyētl	—	nōstê′	—
To give	gyɛnā′m	gyinā′m	me-ga-nī-āh′	na	—
To laugh	sis'a′qs	hîs'ā′qs	na-is-tlook′	gyēîntqô′	—
To cry	wihā ut	wuyî′tk'	eh-tshih	ēfa′	—

Additional Words in Gibbs's Vocabulary of the TkulHiyogoā′ikc.

my son, au-kwa.
lad, sk-e′h; *as when an Indian chief talks of his young men*, i.e. *his unmarried followers, he terms them* See-sk-e′h, *my boys or lads.*
Indians, people, kwun-·a-runt.
my eyebrow, sne′hts-eh-le.
my thigh, so-ru′rs.
calf of my leg, sku′t-ta.
cedar, kl-sklo-ne-ye.
oak, tsoo-we′h.
fat, che-kuch.
buffalo, moos-e-moos-he (*Chinook*).
prairie wolf, sul-i-kul (sin-c-kul *Chehalis*).
black-tailed deer, woon-ins-kunnie.
male elk, t'chest-hu.
female elk, tseh-a-ka-you.
tortoise, wit-la-hoh (it-lah-wa, *Chinook*).
pigeon, hum-ehm (hum-o′h, *Nisqualli*)
winter salmon, see-ahie.
sturgeon, wuz-e-te′h-nie.
land otter, che-leh-zie.
cougar, wutche-nai-kul.
wild cat, wun-el-käits-le.
raccoon, kwa′hlas.
fawn, till-kah.
calf of elk, chaht-la-zoo-lie.
tamanous of medicine, tee-e′nn.
tamanous of feasts, tseh-kwa′ss.
small haiqua, ret-eh-sie.
large haiqua, te-ko-et-sie.
plank, klush-ts.
basket, hah-tsa.
gun, shwool-wool-tch-re.
Chinook canoe, kl'whee′-at.
year, tl-ne′h-ta
handsome (*good*), n'zo′-an.
ugly (*bad*), nt-sunn.
eleven, kwin-eh-she-a choot-tle-e′h.
twelve, kwin-eh-she-a choot-na′ht-keh.
thirty, tah klitch-e′hl-tcho.
one hundred, kwan-ne-san-ne-tchehl-choot.
hungry, tche′h-a.
thirsty, za-re′hl-tcha.
G— d—n you, cheh-sl-ka′hne.
thank you, che-nâl-yah.
thank you very much, see-nâ-châl-yah

Words of the TkulHiyogoā′ikc obtained from 'Catherine,' 1894.

water, tō (*Gibbs:* toh).
sky, yā.
salmon, ka′mō's.
bear, tɛ′lsɛnē (*Gibbs:* til-e-zun).
dog, na′ttaii (*Gibbs:* klehl).
old woman, stsiā′nē.
pole for poling canoe, tck·u′lk·ulē.
come! nē′astō (*Gibbs:* neh-as-to).
give me! sqā′dō.
give me water to drink! qatc′ē′tltcō tō.

TRANSACTIONS OF THE SECTIONS.

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Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President of the Section—Professor W. M. Hicks, M.A., D.Sc., F.R.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

In making a choice of subject for my address the difficulty is not one of finding material but of making selection. The field covered by this Section is a wide one. Investigation is active in every part of it, and is being rewarded with a continuous stream of new discoveries and with the growth of that co-ordination and correlation of facts which is the surest sign of real advancement in science. The ultimate aim of pure science is to be able to explain the most complicated phenomena of nature as flowing by the fewest possible laws from the simplest fundamental data. A statement of a law is either a confession of ignorance or a mnemonic convenience. It is the latter if it is deducible by logical reasoning from other laws. It is the former when it is only discovered as a fact to be a law. While, on the one hand, the end of scientific investigation is the discovery of laws, on the other, science will have reached its highest goal when it shall have reduced ultimate laws to one or two, the necessity of which lies outside the sphere of our cognition. These ultimate laws—in the domain of physical science at least—will be the dynamical laws of the relations of matter to number, space, and time. The ultimate data will be number, matter, space, and time themselves. When these relations shall be known, all physical phenomena will be a branch of pure mathematics. We shall have done away with the necessity of the conception of potential energy, even if it may still be convenient to retain it; and—if it should be found that all phenomena are manifestations of motion of one single continuous medium—the idea of force will be banished also, and the study of dynamics replaced by the study of the equation of continuity.

Before, however, this can be attained, we must have the working drawings of the details of the mechanism we have to deal with. These details lie outside the scope of our bodily senses; we cannot see, or feel, or hear them, and this, not because they are unseeable, but because our senses are too coarse-grained to transmit impressions of them to our mind. The ordinary methods of investigation here fail us; we must proceed by a special method, and make a bridge of communication between the mechanism and our senses by means of hypotheses. By our imagination, experience, intuition we form theories; we deduce the consequences of these theories on phenomena which come within the range of our senses, and reject or modify and try again. It is a slow and laborious process. The wreckage of rejected theories is appalling; but a knowledge of what actually goes on behind what we can see or feel is surely if slowly being attained. It is the rejected theories which have been the necessary steps towards formulating others nearer the truth. It would be an extremely interesting study to consider the history of these discarded theories; to show the part they have taken in the evolution of truer conceptions, and to trace the persistence and modification of typical ideas from one stratum of theories to a later. I propose, however, to ask your attention for a short time to one of these special theories—or rather to two related theories—on the constitution of matter and of the ether. They are known as the vortex atom theory of matter, and the vortex sponge theory of the ether. The former has been before the scientific world for a quarter of a century, since its first suggestion by Lord Kelvin in 1867, the second for about half that time. In what I have to say I wish to take the position not of an advocate for or against, but simply as a prospector attempting to estimate what return is likely to be obtained by laying down plant to develop an unknown district. This is in fact the state of these two theories at present. Extremely little progress has been made in their mathematical development, and until this has been done more completely we cannot test them as to their powers of adequately explaining physical phenomena.

The theory of the rigid atom has been a very fruitful one, especially in explaining the properties of matter in the gaseous state; but it gives no explanation of the apparent forces which hold atoms together, and in many other respects it requires supplementing. The elastic solid ether explained much, but there are difficulties connected with it—especially in connection with reflection and refraction—which decide against it. The mathematical rotational ether of MacCullagh is admirably adapted to meet these difficulties, but he could give no physical conception of its mechanism. Maxwell and Faraday proposed a special ether for electrical and magnetic actions. Maxwell's identification of the latter with the luminiferous ether, his deduction of the velocity of propagation of light and of indices of refraction in terms of known electrical and magnetic constants, will form one of the landmarks in the history of science. This ether requires the same mathematical treatment as that of MacCullagh. Lord Kelvin's gyrostatic model of an ether is also of the MacCullagh type. Lastly, we have Lord Kelvin's labile ether, which again avoids the objections to the elastic solid ether. In MacCullagh's type of ether the energy of the medium when disturbed depends only on the twists produced in it. This ether has recently been mathematically discussed by Dr. Larmor, who has shown that it is adequate to explain all the various phenomena of light, electricity, and magnetism. To this I hope to return later. Meanwhile, it may be borne in mind that the vortex sponge ether belongs to MacCullagh's type.

Already before a formal theory of a fluid ether had been attempted, Lord Kelvin[1] had proposed his theory of vortex atoms. The permanence of a vortex filament with its infinite flexibility, its fundamental simplicity with its potential capacity for complexity, struck the scientific imagination as the thing which was wanted. Unfortunately the mathematical difficulties connected with the discussion of these motions, especially the reactions of one on another, have retarded the full development of the theory. Two objections in chief have been raised against it, viz. the difficulty of accounting for the densities of various kinds of matter, and the fact that in a vortex ring the velocity of translation decreases as the energy increases. There are two ways of dealing with a difficulty occurring in a general theory—one is to give up the theory, the other is to try to see if it can be modified to get over the difficulty. Such difficulties are to be welcomed as means of help in arriving at greater exactness in details. It is a mistake to submit too readily to crucial experiments. The very valid crucial objection of Stokes to MacCullagh's ether is a case in point. It drew away attention from a theory which, in the light of later developments, gives great hope of leading us to correct ideas. As Larmor has pointed out, this objection vanishes when we have intrinsic rotations in the ether itself. A special danger to guard against is the importation into one theory of ideas which have grown out of one essentially different. This

[1] Vortex Atoms,' *Proc. Roy. Soc. Edin.*, vi. 94; *Phil. Mag.* (4), 34.

remark has reference to the apparent difficulty of decrease of velocity with increased energy.

Maxwell was, I believe, the first to point out the difficulty of explaining the masses of the elements on the vortex atom hypothesis. To me it has always appeared one of the greatest stumbling-blocks to the acceptance of the theory. We have always been accustomed to regard the ether as of extreme tenuity, as of a density extremely though not infinitely smaller than that of gross matter, and we carry in our minds that Lord Kelvin has given an inferior limit of about 10^{-19}. There are two directions in which to seek a solution. The first is to cut the knot by supposing that the atoms of gross matter are composed of filaments whose rotating cores are of much greater density than the ether itself. The second is to remember that Lord Kelvin's number was obtained on the supposition of elastic solid ether, and does not necessarily apply to the vortex sponge. Unfortunately, however, for the first explanation, the mathematical discussion[1] shows that a ring cannot be stable unless the density of the fluid outside the core is equal to, or greater than, that inside. This instability also cannot be cured by supposing an additional circulation added outside the core. Unless, therefore, some modification of the theory can be made to secure stability, this idea of dense fluid cores must be given up.

We seem, therefore, forced back to the conclusion that the density of the ether must be comparable with that of ordinary matter. The effective mass of any atom is not composed of that of its core alone, but also of that portion of the surrounding ether which is carried along with it as it moves through the medium. Thus a rigid sphere moving in a liquid behaves as if its mass were increased by half that of the displaced liquid. In the case of a vortex filament the ratio of effective to actual mass may be much larger. In this explanation the density of the matter composing an atom is the same for all, whilst their masses depend on their volumes and configurations combined. Now the configuration alters with the energy, and this would make the mass depend to some extent at least on the temperature. However repugnant this may be to current ideas, we are not entitled to deny its possibility, although such an effect must be small or it would have been detected. Such a variation, if it exists, is not to be looked for by means of the ordinary gravitation balance, but by the inertia or ballistic balance. The mass of the core itself remains, of course, constant, but the effective mass—that which we can measure by the mechanical effects which the moving vortex produces—is a much more complicated matter, and requires much fuller consideration than has been given to it.

The conditions of stability allow us to assume vacuous cores or cores of less density than the rest of the medium. If we do this then the density of the ether itself may be greater than that of gross matter. Until, however, we meet with phenomena whose explanation requires this assumption, it would seem preferable to take the density everywhere the same. In this case the density of the ether must be rather less than the apparent density of the lightest of any of the elements, taking the apparent density to mean the effective mass of a vortex atom per its volume. This will probably be commensurable with the density of the matter in its most compressed state, and will lie between ·5 and 1—comparable, that is to say, with the density of water. Larmor,[2] from a special form of hypothesis for a magnetic field in the rotationally elastic ether, is led to assign a density of the same order of magnitude. If the density be given it is easy to calculate the intrinsic energy per c.c. in the medium. The velocity of propagation of light in a vortex sponge ether, as deduced by Lord Kelvin,[3] is ·47 times the mean square

[1] An error in the expression on p. 768 of 'Researches in the Theory of Vortex Rings,' *Phil. Trans.*, pt. ii. 1885, vitiates the conclusion there drawn. If this be corrected the result mentioned above follows. See also Basset, *Treatise on Hydrodynamics*, § 338, and *Amer. Jour. Math.*

[2] 'A Dynamical Theory of the Electric and Luminiferous Medium,' *Phil. Trans.*, 1894, A. p. 779.

[3] 'On the Propagation of Laminar Motion through a Turbulently Moving Inviscid Liquid,' *Phil. Mag.*, October 1887.

velocity of the intrinsic motion of the medium. This gives for the mean square velocity $6{\cdot}3 \times 10^{10}$ cm. per second. If we follow Lord Kelvin and use for comparison the energy of radiation per c.c. near the sun, or say 1·8 erg per c.c., the resulting density will be 10^{-21}. The energy per c.c. in a magnetic field of 15,000 c.g.s. units is about 1 joule. If we take this for comparison we get a density of 10^{-14}. But the intrinsic energy of the fluid must be extremely great compared with the energy it has to transmit. If it were a million times greater the density would still only amount to 10^{-8}—comparable with the density of the residual gas in our highest vacua. To account for the density of gross matter on the supposition that it is built up out of the same material as the ether leads to a density between ·5 and 1. This gives the enormous energy of 10^{14} joules per c.c. In other words, the energy contained in one cubic centimetre of the ether is sufficient to raise a kilometre cube of lead 1 metre high against its weight. Thus the difficulty in explaining the mass of ordinary matter seems to reduce itself to a difficulty in believing that the ether possesses such an enormous store of energy. It may be that there are special reasons against such a large density. Larmor refers to the large forcives which would be called into play by hydrodynamical motions. Perhaps an answer to this may be found in the remark that where all the matter is of the same density the motions are kinematically deducible from the configuration at the instant, and are independent of the density. It is only where other causes act, such, *e.g.*, as indirectly depend on the mean pressure of the fluid or where vacuous spaces occur, that the actual value of the density may modify the measurable forcives.

Ever since Professor J. J. Thomson proved that a vortex atom theory of matter is competent to serve as a basis of a kinetic theory of gases, it has been urged by various persons as a fatal objection that the translation velocity of the atoms falls off as the temperature rises. I must confess this objection has never appealed to me. Why should not the velocity fall off? The velocity of gaseous molecules has never been directly observed, nor has it been experimentally proved that it increases with rise of temperature. We have no right to import ideas based on the kinetic theory of hard discrete atoms into the totally distinct theory of mobile atoms in continuity with the medium surrounding them. Doubtless the molecules of a gas effuse through a small orifice more quickly as the temperature rises, but it is natural to suppose that a vortex ring would do the same as its energy increases. To make the objection valid, it is necessary to show that a vortex ring passing through a small tube, comparable with its own diameter, would pass through more slowly the greater its energy. It is not, however, necessarily the case that in every vortex aggregate the velocity decreases as the energy increases. The mathematical treatment of thin vortex filaments is comparatively easy, and little attention has been paid to other cases. Let us attempt to trace the life history as to translation velocity and energy of a vortex ring. We start with the energy large; the ring now has a very large aperture, and has a very thin filament. As the energy decreases the aperture becomes smaller, the filament thicker, and the velocity of translation greater. We can trace quantitatively the whole of this part of its history until the thickness of the ring has increased to about four times the diameter of the aperture, or perhaps a little further. Then the mathematical treatment employed fails us or becomes very laborious to apply. Till eighteen months ago, this was the only portion of its history we could trace. Then Professor M. J. M. Hill [1] published his beautiful discovery of the existence of a spherical vortex. This consists of a spherical mass of fluid in vortical motion and moving bodily through the surrounding fluid, precisely as if it were a rigid sphere. This enables us to catch a momentary glimpse as it were of our vortex ring some little time after it has passed out of our ken. The aperture has gone on contracting, the ring thickening, and altering the shape of its cross section in a manner whose exact details have not yet been calculated. At last we just catch sight of it again as the aperture closes up. We find the ring has changed into a spherical ball, with still further diminished energy and increased velocity. We then lose sight of it again, but it now lengthens

[1] 'On a Spherical Vortex,' *Phil. Trans.*, 1894.

out, and towards the end of its course approximates to the form of a rod moving parallel to its length through the fluid with energy and velocity which again can be approximately determined. In this part of its life the velocity of translation decreases with decrease of energy. I believe it will be found, when the theory is completely worked out, that the spherical atom is the stage where this reversal of property takes place.

Even in the ring state, however, the change of velocity with energy is very small; much smaller, I think, than is generally recognised. When the energy is increased to twenty times that of the spherical vortex, the velocity is only diminished to two-thirds its previous value. If at ordinary temperatures, say 27° C., the vortex was in the spherical shape, then at 3,000° C. its velocity of translation would only have been reduced to four-fifths its value at the lower temperature, whilst the aperture of the ring would have a radius about 1·4 time that of the sphere. At 2,000° C. the velocity would not differ by much more than one-twentieth from its original value. In fact, near the spherical state the alteration in velocity of translation is very slow. It is therefore possible, that if the atoms of matter be vortex aggregates, the state in which we can experimentally test our theory is just that in which the mathematical discussion fails us. Other modifications tend to diminish this change of velocity. I will refer here to three only. The first is that of hollow vortices. We must not, however, postulate vacuous atoms without any rotational core at all; for in this case we should probably lose the essential property of permanence. The question has not been fully investigated, but there can be little doubt but that by diminishing the energy of a completely hollow vortex we can cause it to disappear. We can certainly create one in a perfect fluid. Secondly, J. J. Thomson has shown that if a molecule be composed of linked filaments, the energy increases as the components move further apart. In such a case an extra supply of energy goes to expanding the molecule, and less, if any, to increasing the aperture. Lastly, a modification of the atomic motion to which I shall refer later, and which seems called for to explain the magnetic rotation of the plane of polarisation of light, will also tend to lessen the change of size, and therefore change of velocity with change of energy, even if it does not reverse the property.

If we pass on to consider how a vortex atom theory lends itself to the explanation of physical and chemical properties of matter independently of what may be called ether relations, we find that we owe almost all our knowledge on this point to the work of Professor J. J. Thomson,[1] which obtained the Adams' Prize in 1882. This, however, is confined to the treatment of *thin* vortex rings, still leaving a wide field for future investigation in connection with thick rings and with vortex aggregates which produce no cyclosis in the surrounding medium. His work is an extremely suggestive one. He shows that such a theory is capable not only of explaining the gaseous laws of a so-called perfect gas, but possibly also the slight deviations therefrom. Quite as striking is his explanation of chemical combination—an explanation which flows quite naturally from the theory. A vortex filament can be linked on itself: two or more can be linked together, like helices drawn on an anchor ring; or, lastly, several can be arranged together like parallel rings successively threading one another. In the latter case, for such an arrangement to be permanent, the strengths of each ring must be the same, and further, not more than six can thus be combined together. The linked vortices will be in permanent combination on account of their linkedness; the other arrangement may be permanent if subject to no external actions. If, however, they are disturbed by the presence of other vortices they may break up. When atoms are thus combined to form a compound, a certain number of molecules will always be dissociated; the compound will be permanent when the ratio of the average paired time to the unpaired time of any atom is large. Thomson considers every filament to be of the same strength. Then an atom consisting of two links will behave like a ring of twice the strength, one of three links, of three times the strength, and so on. On this theory chemical compounds are to be regarded as systems of rings, not linked

[1] 'A Treatise on the Motion of Vortex Rings.' Macmillan, 1883.

into one another but close together, and all engaged in the operation of threading each other. The conditions for permanence are: (1st) the strength of each ring must be the same, (2nd) the number must be less than 6. Now apply this. H and Cl have equal linkings, therefore equal strength. Consequently we can have molecules of HCl, or any combinations up to 6 atoms per molecule, although the simpler one is the most likely. O has twice the linking, therefore the strength double. Hence one of H and one of O cannot revolve in permanent connection. We require first to arrange two of H together to form one system. This system has the same strength as O, they can therefore revolve in permanent connection, and we get the water molecule. *Or* we may take two of the O atoms and one of the double H molecule, and they can form a triple system of three rings threading one another in permanent connection, and we get the molecule H_2O_2. This short example will be sufficient to indicate how the theory gives a complete account of valency.

The energy of rings thus combined is less than when free; consequently they are stable, and the act of combination sets free energy. Further, Thomson points out that for two rings to combine their sizes must be about the same when they come into proximity; consequently combination can only occur between two limits of temperature corresponding to the energies within which the radii of both kinds of rings are near an equality.

We can easily extend Thomson's reasoning to explain the combination of two elements by the presence of a third neutral substance. Call the two elements which are to combine A and B, and the neutral substance C. The radii of A and B are to be supposed too unequal to allow them to come close enough together to combine. If now at the given temperature the C atom has a radius intermediate to those of A and B, it is more nearly equal to each than they are to one another; C picks up one of A, and after a short time drops it; A will leave C with its radius brought up (say) to closer equality with it. The same thing happens with the B atoms, and they leave C with their radii brought down to closer equality with it. The result is that A and B are brought into closer equality with one another, and if this is of sufficient amount, they can combine and do so, while C remains as before and apparently inert.

Thomson's theory of chemical combination applies only to thin rings. Something analogous may hold also for thick rings, but it is clearly inapplicable to vortex aggregates similar to that of Hill's. We are not confined, however, to this particular kind of association of vortex atoms in a molecule. For instance, I have recently found[1] that one of Hill's vortices can swallow up another and retain it inside in relative equilibrium. The matter requires fuller discussion, but it seems to open up another mode of chemical combination.

A most important matter which has not yet been discussed at all is the relation between the mean energy of the vortex cores, and the energy of the medium itself when the atoms are close enough to affect each other's motions (as in a gas). The fundamental ideas are quite different from those underlying the well-known kinetic theory of gases of hard atoms. Nevertheless, many of the results must be very similar, based as both are on dynamical ideas. Whether it will avoid certain difficulties of the latter, especially those connected with the ratio of the specific heats, remains to be seen. The first desideratum is the determination of the equilibrium of energy between vortices and medium, and before this is done it is useless to speculate further in this region.

A vortex atom theory of matter carries with it the necessity of a fluid ether. If such a fluid is to transmit transversal radiations, some kind of quasi-elasticity must be produced in it. This can be done by supposing it to possess energetic rotational motions whose mean velocity is zero, within a volume whose linear dimension is small compared with the wave length of light, but whose velocity of mean square is considerable. That an ether thus constituted is capable of transmitting transverse vibrations I showed before this Section at the Aberdeen meeting of the Association,[2] by considering a medium composed of closely packed discrete

[1] Not yet published.

[2] 'On the Constitution of the Luminiferous Ether on the Vortex Atom Theory,' *Brit. Assoc. Reports*, 1885, p. 930.

small vortex rings. Lord Kelvin[1] at the Manchester meeting discussed the question much more thoroughly and satisfactorily, and deduced that the velocity of propagation was $\sqrt{2/3}$ times the velocity of mean square of the turbulent motion. We can make little further progress until we know something of the arrangement of the small motions which confer the quasi-rigidity. This may be completely irregular and unsteady, or arranged in some definite order of steady motions. I am inclined to the view that the latter is nearer the truth. In this case we should expect a regular structure of small cells in which the motions are all similar. By the word cell I do not mean a small vessel bounded by walls, but a portion of the fluid in which the motion is a complete system in itself. Such a theory might be called a cell theory of the ether. The simplest type perhaps is to suppose the medium spaced into rectangular boxes, in each of which the motion may be specified as follows. Holding the box with one set of faces horizontal the fluid streams up in the centre of the box, then turns round, flows down the sides and up the centre again. In fact it behaves like a Hill's vortex squeezed from a spherical into a box form. Each box has thus rotational circulation complete in itself. The six adjoining compartments have their motion the same in kind but in the reverse direction, and so on. In this way we get continuous and energetic small motions throughout the medium, and the state is a stable one. If there is a shear, so that each cell becomes slightly rhomboidal, the rotational motions inside tend to prevent it, and thus propagate the disturbance, but the cells produce no effect on the general irrotational motion of the fluid, at least when the irrotational velocities are small compared with those of the propagation of light. In this case the rate at which the cells adjust themselves to an equilibrium position is far quicker than the rate at which this equilibrium distribution is disturbed by the gross motions. The linear dimensions of the cells must be small compared with the wave lengths of light. They must probably be small also compared with the atoms of gross matter, which are themselves small compared with the same standard.

We may regard each cell as a dynamical system by itself, into which we pour or take away energy. This added energy will depend only on the shape into which the box is deformed. We may then, for our convenience in considering the gross motions of the medium as a whole, *i.e.* our secondary medium, regard these as interlocked systems, neglect the direct consideration of the motions inside them, but regard the energy which they absorb as a potential function for the general motion. This potential function will contain terms of two kinds, one involving the shear of the cells, and this shear will be the *same* as that of the rotational deformation in the secondary medium. The second will depend on alterations in the ratios of the edges of the cells.[2] The former will give rise to waves of transversal displacements. The second cannot be transmitted as waves, but may produce local effects. If a continuous solid be placed in such a medium, the cells will rearrange themselves so as to keep the continuity of their motions. The cells will become distorted (but without resultant shear), and a static stress will be set up. We have then to deal with the primary stuff itself, whose rotation gives a structure to the ether, and the structural ether itself. The former we may call the primary medium. The ether which can transmit transversal disturbances, and which is built up out of the first, we may call the secondary medium. Whether an atom of matter is to be considered as a vortical mass of the primary or of the secondary medium is a matter to be left open in the present state of the theory.

At the Bath meeting of this Association, I sketched out a theory of the electrical action of a fluid ether in which electrical lines of force were vortex filaments combined with an equivalent number of hollow vortices of the same vortical strength.[3] An electric charge on a body depended on the number of ends of filaments abutting on it, the sign being determined by the direction of rotation of the filament looked at from the body. This theory gave a complete account of

[1] 'On the Vortex Theory of the Luminiferous Ether,' *Brit. Assoc. Reports*, 1887, p. 486, also *Phil. Mag.*, October 1887, p. 342.

[2] Including other changes of form involving no rotations.

[3] 'A Vortex Analogue of Static Electricity,' *Brit. Assoc. Rep.*, 1888, p. 577.

electrostatic actions, both quantitatively and qualitatively, and a more speculative one as to currents and magnetism. I could only succeed in proving at that time that if the filaments were distributed according to the same laws as electric lines of force, the distribution would be one of equilibrium. Larmor[1] has recently proved that this is also the necessary distribution for any type of a rotationally elastic ether, and consequently also for this particular case. Currents along a wire were supposed to consist of the ends of filaments running along it, with disappearance of the hollow companions, the filaments producing at the same time a circulation round the wire. A magnetic field was thus to be regarded as a flow of the ether, but probably with the necessary accompaniment of rotational elements in it.

This latter, however, was clearly wrong, because each kind of filament would produce a circulation in opposite directions. The correct deduction would have been to lay stress on the fact that the field is due to the motion through the stationary ether of the vortex filaments, the field being perpendicular to the filament and to its direction of motion. This motion would doubtless produce stresses in the cell-ether due to deformations of the cells, and be the proximate cause of the mechanical forces in the field. In any case, it is not difficult to show that a magnetic field cannot be due to an irrotational flow of the ether alone.[2] Such electrostatic and magnetic fields produce states of motion in the medium, but no bodily flow in it; consequently we ought not to expect an effect to be produced on the velocity of transmission of light through it.

The fundamental postulate underlying this explanation of electric action is that when two different kinds of matter are brought into contact a distribution of vortex filaments in the neighbourhood takes place, so that a larger number stretch from one to the other than in the opposite direction—the distinction between positive and negative ends being that already indicated. To see how such a distribution may be caused, let us consider each vortex atom to be composed of a vortical mass of our secondary medium or cell-structure ether. The atom is much larger than a cell, and contains practically an infinite number of them. It is a dynamical system of these cells with equilibrium of energy throughout its volume. The second atom is a dynamical system with a different equilibrium of energy. Where they come into contact there will be a certain surface rearrangement, which will show itself as a surface distribution of energy in a similar manner to that which exists between a molar collection of one kind of molecules in contact with one of another, and which shows itself in the phenomenon which we call surface tension. In the present case the effect may take place at the interface of two atomic systems in actual contact, or be a difference effect between the two interfaces of the ether and each atom when the latter are sufficiently close. The surface effect we are now considering shows itself as contact electricity.

Such a distribution of small vortex filaments, stretching from one atom to another, will tend to hold them together. We therefore get an additional cause for aggregation of atoms. This does not exclude the others already referred to. They may all act concurrently, some producing one effect, some another—one combining, perhaps, unknown primitive atoms into elements, one elements into chemical compounds, and another producing the cohesion of matter into masses.

On this theory the difference between a conductor and a dielectric is that in a dielectric the ends of the filaments cannot pass from atom to atom, possibly

[1] 'A Dynamical Theory of the Electric and Luminiferous Medium,' *Phil. Trans.*, 1894, p. 748.

[2] To prove this, consider a straight conductor moving parallel to itself and perpendicular to a uniform magnetic field. There exists a permanent potential difference between its ends. If, however, the field consists of a flow of ether, the effect is the same as if the conductor is at rest, and the direction of the magnetic field shifted through an angle. But this is the case of a conductor at rest in a field, and there is therefore no potential difference between the ends. Hence a magnetic field must consist of some structure across which the conductor cuts. A field may possibly demand a flow of the ether, but, if so, it must carry in it some structure definitely oriented at each point to the direction of flow.

because the latter never come into actual contact. In a conductor, however, we are to suppose that the atomic elements can do so. When a current is flowing, a filament and its equivalent hollow stretch between two neighbouring atoms, they are pulled into contact, or their motions bring them into contact, the hollow disappears, and the rotational filament joins its two ends and sails away as a small neutral vortex ring into the surrounding medium, or returns to its function as an ether cell. The atoms being free are now pulled back to perform a similar operation for other filaments. The result is that the atoms are set into violent vibrations, causing the heating of the conductor. When, however, the metal is at absolute zero of temperature, there is no motion, the atoms are already in contact, and there is no resistance, as the observation of Dewar and Fleming tends to show. Further, as the resistance depends on the communication of motion from molecule to molecule, we should expect the electrical conductivity of a substance to march with its thermal conductivity. Again, on this theory the resistance clearly increases with increase of distance between atoms—*i.e.*, with increase of temperature. On the contrary, in electrolytic conduction the same junction of filament ends is brought about, not by oscillations of molecule to molecule, but by disruption of the molecule and passage of atom to atom. In this case conduction is easier the more easily a molecule is split up, and thus resistance decreases with increase of temperature. To explain the laws of electrolysis it is only necessary to assume that the strengths of all filaments are the same. A similar hypothesis, as we have seen, lies at the basis of J. J. Thomson's explanation of chemical combination, although it is not necessarily the case that we are dealing with the same kind of filaments. It is evident that the theory easily lends itself to his views as to the mechanism of the electric discharge through gases. The *modus operandi* of the production of the mechanical forcive on a conductor carrying a current in a magnetic field and of electrodynamic induction is not clear. Probably the full explanation is to be found in the stresses produced in the ether owing to the deformation of the cells by the passage of the filaments through them. The fluid moves according to the equation of continuity without slip, and subject to the surface conditions at the conductors. This motion, however, distorts the cells, and stresses are called into play. Any theory which can explain the mechanical forcives and also Ohm's law, must, on the principles of the conservation of energy, also explain the induction of currents.

The magnetic rotation of the plane of polarisation of light does not depend on the structure of the ether, or on the magnetic field itself, but is a result of the atomic configuration of the matter in the field modified by the magnetism. It is generally recognised as caused by something in the field rotating round the direction of the magnetic lines of force. Now the vortex atom, as usually pictured, is incapable of exhibiting this property. It is, however, an interesting fact, and one which I hope to demonstrate to this Section during the meeting, that a vortex ring can have two simultaneous and independent cyclic motions—one the ordinary one, and another which is capable of producing just the action on light which shows itself as a rotation of the plane of polarisation. The motion is rather a complicated one to describe without a diagram, but an idea of its nature may be obtained by considering the case of a straight cylindrical vortex. The ordinary straight vortex consists, as every one knows, of a cylinder of fluid revolving like a solid, and surrounded by a fluid in irrotational motion. In the core the velocity increases from zero at the axis to a maximum at its surface. Thence it continuously decreases in the outer fluid as the distance increases. Everywhere the motion is in a plane perpendicular to the axis. Let us now consider a quite different kind of vortical motion. Suppose the fluid is flowing along the core like a viscous fluid through a pipe; the velocity is zero at the surface and a maximum at the axis. Everywhere it is parallel to the axis, the vortex lines are circles in planes perpendicular to the axis, and concentric with it. Since the velocity at the surface of the core is zero, the surrounding fluid is also at rest. Now superpose this motion on the previous one, and it will be found to be steady. If a short length of this vortex be supposed cut off, bent into the shape of a circle and the ends joined, we shall have a very rough idea of the compound vortex ring of which I speak. I say a very rough idea, because the actual state of motion in a ring vortex or a Hill's vortex is not quite so simple as the analogy might lead one to think.

Now a compound vortex atom of this kind is just what we want to produce rotation of the plane of polarisation of light. The light passing through such a vortex has the direction of vibration twisted in the wave front. In ordinary matter no such rotation is produced, because the various atoms are indifferently directed, and they neutralise each other's effects. Let, however, a magnetic field be produced, and they will range themselves so that, on the average, the primary [1] circulations through the apertures will point in the direction of the field. Consequently the average direction of the secondary spin will be in planes perpendicular to this, and will rotate the plane of polarisation of any light whose wave front passes them. The rotation is produced only on the light which is transmitted *through* the vortex. The rotation observed is a resultant effect. In fact it is clear that in the case of refraction the optical media belong to the type in which every portion transmits the light, and not to the type in which refraction is produced by opaque bodies embedded in the ether. The atoms are only opaque if they contain vacuous cores. The question of the grip of the particles on the ether does not enter, but difference of quality—showing itself in refraction and dispersion—is due to difference in average rotational quasi-elasticity produced by the atomic circulations, and possibly absorption is due to precessional and nutational motion set up by the secondary spins. These, however, are perhaps rather vague speculations.

Instead of attempting to invent ethers, to deduce their properties from their specifications, and then seeing whether they fit in with experience, we may begin half way. We may assume different forms for the function giving the energy of the medium when disturbed, apply general dynamical methods, and distinguish between those which are capable of explaining the phenomena we are investigating and those which are not. Invention is then called upon to devise a medium for which the desired energy-function is appropriate. This was the method applied by MacCullagh to the luminiferous ether. He obtained an algebraical form of the energy function which completely satisfied the conditions for a luminiferous ether; its essential property being that the energy depended only on the rotational displacements of its small parts. He was unable, however, to picture a stable material medium which would possess this property. We recognise now that such a medium is possible if the rotational rigidity is produced by intrinsic motions in the small parts of the medium of a gyrostatic nature. In a most masterly manner Larmor [2] has recently investigated by general dynamical methods the possibility of explaining electric and magnetic phenomena by means of the same energy function. Electric lines of force are rotational filaments in the ether,[3] similar in fact to those I suggested at Bath, whilst a magnetic field consists of a flow of the ether. The same difficulty in accounting for electro-dynamic induction arises, but the general form of the equations for the electro-dynamic and magnetic fields are the same as those generally received.

Towards the end of this paper he is led to postulate a theory of electrons whose convection through the ether constitutes an electric current. Two rotating round each other are supposed to produce the same effect as a vortex ring. The mass of ordinary matter is attributed to the electric inertia of these electrons. The electron itself is a centre or nucleus of rotational strain. If I express a doubt as to the possibility of the existence of these nuclei as specified, I do so with great diffidence.[4]

[1] 'Primary' refers to the motion as usually understood; 'secondary,' to the superposed, as explained above.

[2] 'A Dynamical Theory of the Electric and Luminiferous Medium,' *Phil. Trans.*, 1894.

[3] The necessity that the filaments shall be in pairs does not seem to be recognised. This is, however, essential. Moreover, if the complementary circulations of the filaments between (say) a plate condenser be placed otherwhere than in the same region, the filaments between the plates must rotate as a whole; that is, an electric field would always be combined with a magnetic one.

[4] It would appear that the same results would flow if two particles oppositely electrified—*i.e.* joined by two complementary filaments, as already described—were to rotate round each other.

Whether they can or cannot exist, however, the general results of the investigation are not affected.

Since this paper was published Larmor has read a second one on the same subject before the Royal Society, developing further his theory of the electron. The publication of this will be awaited with interest. It is impossible in an address such as this to go *seriatim* into the numerous points which he takes up and illuminates, because the mathematical treatment of the general question does not lend itself easily to oral exposition even to an audience composed of professed mathematicians. There is no doubt but that this paper has put the theory of a rotationally elastic ether—and with it that of a fluid vortex ether—on a sounder basis, and will lead to its discussion and elucidation by a wider circle of investigators.

One further class of physical phenomena yet remains, viz., those of gravitation. The ether must be capable of transmitting gravitational forces as well as electric and optical effects. Does the rotational ether give any promise of doing this? No satisfactory explanation of gravitation on any theory has yet been offered. Perhaps the least unsatisfactory is that depending on the vortex atom theory of matter, which attributes it to pulsations of hollow vortex atoms. But this necessitates that they should all pulsate with the same period and in the same phase. It is very difficult to conceive how this can happen, unless, as Larmor suggests, all matter is built up of constant elements like his electrons, whose periods are necessarily all alike. It is possible that the vortex cell theory of the ether, of which I have already spoken, may suffice to explain gravitation also. The cells, besides their rotational rigidity, have, in addition, as we saw, a peculiar elasticity of form. To get an idea of how this theory may account for weight, let us suppose the simplest case where all the cells are exactly alike, and the medium is in equilibrium. Now suppose one of the cells begins to grow. It forces the medium away on all sides; the cells will be distorted in some definite way, and a strain set up. Further, this strain will be transmitted from the centre, so that the total amount across any concentric sphere will be the same. Stresses will therefore be set up in the whole medium. If a second cell begins to grow at another place it will produce also a state of strain, the total strain depending on the presence of both. The stresses called into play in the medium will produce a stress between the bodies, but it is questionable whether it would be inversely as the square of the distance. Whether it would be an attraction or repulsion can only be determined by mathematical investigation. The problem is quite determinate, though probably a very difficult one, and would be of mathematical interest quite apart from its physical importance. Since apparently the phenomena of gravitation have no direct interaction with those of light and electricity, whilst the mind rejects the possibility of two different media occupying the same space, we seem driven to look for it in an independent structure of the same medium. Such a structure is already to our hands, with its effects waiting to be determined. It may well be that it may prove to be the cause we are seeking.

The rapid survey I have attempted to make is no doubt a medley of suppositions and inferences combined with some sound deductions. This is the necessary consequence of a prospecting survey in a region whose surface has been merely scratched by pioneers. My object has been to show that this theory of an ether, based on a primitive perfect fluid, is one which shows very promising signs of being able to explain the various physical phenomena of our material universe. Probably, nay certainly, the explanations suggested are not all the true ones. Some will have to be given up, others modified with further knowledge. We cannot proceed to particularise in our secondary hypotheses until we know more about the properties of such media as we have been considering. Every special problem solved in vortex motion puts us in a position to form clearer ideas of what can and what cannot happen. The whole question of vortex aggregates and their interactions is

[1] 'On the Problem of Two Pulsating Spheres in a Fluid,' *Proc. Camb. Phil. Soc.*, iii. p. 283.

practically untouched, and a rich field is open for mathematical investigation in this portion only of the subject. In all cases, whether a fluid ether is an actual fact or not, the results obtained will be of special interest as types of fluid motion. It is at present a subject in which the mathematicians must lead the attack. I shall have attained my object in choosing this subject for my address, if by it I can induce some of our younger mathematicians to take it up, and work out its details.

The following Papers and Report were read:—

1. *On the Reichsanstalt, Charlottenburg, Berlin.* *By* Sir Douglas Galton, *K.C.B.*

The original idea of this establishment emanated from von Helmholtz and Werner von Siemens. The site at Charlottenburg, about 11 acres, was given by Dr. Werner von Siemens, and he contributed 250,000 marks (12,000*l.*) in aid of the building. Thereupon the German Government undertook the construction of the building and its endowment.

The design of the buildings and the working arrangements were planned by von Helmholtz, who was appointed its first director. One portion of the establishment is complete and in operation. The buildings for the other portion are still in course of erection.

The scientific work of the second portion is meanwhile being partially carried on in the Royal Technical High School, situated at Charlottenburg.

As the establishment is thus still far from complete, the cost of the building and equipment, and of the annual expenditure for maintenance, cannot be given.

The object of the establishment may be defined to be '*the development of pure scientific research, and the promotion of new applications of science for industrial purposes.*'

The establishment consists of two divisions. The first is charged with pure research, and is at the present time engaged in various thermal, optical, and electrical and other physical investigations.

The reports on many branches of work which have been done in this establishment are appended to the paper.

The second branch is employed in delicate operations of standardising and testing to assist the wants of outside research students, and to facilitate applications of science to industries. As, for instance, comparison with standards of the dilatation of metals, of electrical resistances, of electric and other forms of light, of lenses, of pressure gauges, of recording instruments, thermometers, pyrometers, and tuning-forks, experiments on the qualities of glass, examination of oil-testing apparatus, viscosity of glycerine, &c.

The plans exhibited give a general idea of the size of the establishment, which stands in its own grounds, of which the space not covered by buildings is laid out in gardens.

The principal building is occupied by the first division; it faces the north-west, and stands at some distance back from the road. This building is about 100 feet long and 85 feet deep. It has three floors of laboratories, and a basement which stands on a mass of cement concrete 2 metres thick, so as to protect the apparatus from vibration; but notwithstanding every precaution, the passing of heavy waggons in the road occasions some movement. An electric tramway is talked of. If this be constructed, serious injury will result to the institution.

In this building there are thirty separate apartments devoted to laboratories, in addition to the several official rooms required for the director and staff, and there is also in the building a large and excellent library of works on pure and applied science.

To the south of this, and parallel to it, is the building for the second division. This building is nearly 200 feet long, and there are two wings, each of which projects to the south to a distance of nearly 95 feet. This building also is three storeys in height.

In the second division there are about forty-one or forty-two apartments devoted to laboratories, in addition to a considerable number of rooms required for the director, the clerks, and the staff, and for a small library.

Towards the front on the eastern side, but nearer the road, is the director's house. On the western side is a house which affords apartments for two of the assistants, and a meeting room for the Board of Management and subsidiary clerks' offices. Behind the latter building, on the west side, are placed the engine house, and rooms for dynamos and storage batteries, as well as laboratories for operations in which the use of cold air is required. These are in course of construction.

These buildings are equally convenient for the supply of power to both divisions.

Two important questions for a department of pure research are: first, the management and the arrangements for regulating the subjects of research; secondly, the methods of taking stock of the work done in the establishment.

In the Reichsanstalt the President is supreme over the staff. The successor to v. Helmholtz is Dr. Kohlrausch. He takes charge of the first division, viz., that of pure research.

The Director, Professor Hagen, under him, takes charge of the second division.

Each main division is subdivided into separate departments for each branch of research; these are in charge of permanent professors. Each of these has under him the necessary assistants selected for limited periods, and for previous good work in one or other of the universities or scientific schools of Germany.

The general supervision is under a Council, consisting of a President of the Council, who is a Privy Councillor, and twenty-four members, including the President and the Director of the Reichsanstalt; of the other members, about ten are professors, or heads of physical or astronomical observatories connected with the principal universities in Germany. Three are selected from leading firms in Germany, representing mechanical, optical, and electric science, and the remainder are principal scientific officials connected with the Departments of War and Marine, from the Royal Observatory at Potsdam, and from the Royal Commission for Weights and Measures.

This Council is summoned to meet when required, but it generally meets in the winter, for such time as may be necessary, for examining the research work done in the first division during the previous year, and for laying down the scheme for research for the ensuing year, as well as for suggesting any requisite improvements in the second division.

It will be seen that the safeguard for ensuring good research work on subjects of general interest and importance lies first in the judicious selection of the President, Director, and Professors of the Reichsanstalt, and after them in a careful selection of the members of the Board of Management, because they not only arrange the subjects for research, but they also hold an annual stock-taking of work done in the department.

Members of the Board of Management, who are appointed from the various scientific establishments all over Germany, are carefully selected, and are remunerated for their services.

In this country, whilst the more enlightened of the County Councils are forming polytechnic institutions intended to approximate to the higher grade polytechnics in Germany, we have no Government Department which approximates to the Reichsanstalt.

The Standards Department was attached to the Board of Trade in 1878, with the duty of making standards of length, weight, and capacity, and in 1889 it was further empowered to make such new standards for the measurements of electricity, temperature, and gravities as appeared to *be of use for trade*. This department possesses, moreover, under the Gas Acts, powers as to a standard of light.

The object of this department is to meet the requirements of trade. Neither the Nation nor the Government appear to have realised the enormous saving of time and labour which would result from systematic standards for every branch of scientific research, coupled with arrangements for comparison easily accessible to students. There would seem to be some difficulty in altering the functions of the Standards Department so as to combine research with its present duties, nor is it established in a situation where delicate observations could be carried on.

The Incorporated Kew Observatory, which is administered by a Committee under the Royal Society, is situated in an almost ideal locality for observations. It already conducts, on a small scale, some experimental work, and it appears to afford a nucleus which might be gradually extended into an establishment analogous to the Reichsanstalt, provided the Government would countenance its extension on its present site, and aid the scheme with a grant of money. Under these circumstances, I would suggest that the Committee of Section A upon National Laboratories—which appears not to have been re-appointed at Oxford—be now renewed with members added from Section B and Section G, and that it be requested to report:—

(*a*) Upon the functions which an establishment of this nature should fulfil.
(*b*) Upon the system which should be adopted for its control and management.

The Association would then be in a position to approach the Government with a definite proposal, either for the utilisation of the Incorporated Kew Observatory for the purpose, or for some other plan.

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2. *On the Teaching of Geometrical Drawing in Schools.* *By* O. Henrici, *F.R.S.*

The teaching of geometrical drawing in schools is in many respects unsatisfactory. It is at present chiefly regulated by the examinations of the Science and Art Department and those for the entrance into the army. At some schools there are also special classes for those boys who intend to become engineers. The requirements for these are at present quite different. It seems desirable, and not at all difficult, to assimilate the teaching by laying down one rational course, so that all pupils at schools can receive the same instruction, at least in the earlier stages. This should be done first of all without any regard to examinations, the only object being the teaching of the 'art' of geometrical drawing. The syllabus for any examination should then be drawn up in conformity with such a course.

To bring this about a committee of the British Association seems to be the most appropriate means. It would be the duty of such a committee to lay down the outlines of the course, and therefore it would be premature to say much about it at present. A few points, however, may here be touched upon.

First of all it seems necessary to free the subject, at least at the beginning, from all connection with Euclid and his constructions; in fact, geometrical drawing should be begun long before Euclid is tackled. Euclid only knows two drawing instruments, the straight-edge and the pair of compasses for drawing straight lines and circles. To these should be added at once the set-squares and sooner or later the T-square.

The drawing of parallels and perpendiculars should be done by their aid; bisection of lines by their aid and by trial. The first object should be to draw *accurately*.

A great many figures can be drawn, first without circles, where the pupil can judge *for himself* whether his drawing is accurate.

Rules for transforming figures by stretching or by shear may follow, leading to equal and to similar figures.

Such a course will be the very best introduction to Euclid, and will form a natural connection between the *Kindergarten*, which is steadily gaining in importance, and the systematic geometry of Euclid.

Solutions of problems which require a knowledge of Euclid should be attempted only when good progress has been made in this art of drawing.

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3. *Interim Report on Cosmic Dust.*

4. *Report on Underground Temperature.*—See Reports, p. 75.

5. *Report on the Sizes of the Pages of Periodicals.*—See Reports, p. 77.

6. *Report on the Comparison and Reduction of Magnetic Observation.* See Reports, p. 209.

7. *Interim Report on the Comparison of Magnetic Standards.* See Reports, p. 79.

FRIDAY, SEPTEMBER 13.

A joint Meeting with Section B.

The following Papers were read:—

1. *The Refraction and Viscosity of Argon and Helium.* *By* Lord RAYLEIGH, *Sec. R.S.*

As compared with dry air, the refraction (μ—1) of argon is 0·961, and that of helium (prepared by Professor Ramsay) is as low as 0·146.

Dry air being again taken as the standard, the viscosity of argon is 1·21, and that of helium is 0·96.

2. *On Specific Refraction and the Periodic Law, with reference to Argon and other Elements.* *By* Dr. J. H. GLADSTONE, *F.R.S.*

In 1869, 1877, and 1883 the author had shown that the specific refractive energies of the metallic elements are usually in the inverse order of their combining proportions, and that the specific refractive energies of the elements in general are to a certain extent a periodic function of their atomic weights.

The present communication refers to some developments of these old observations.

(1) Argon. The specific refractive energy of argon gas, as reckoned from Lord Rayleigh's data, is 0·159. Deeley had suggested that this property might throw light upon the question whether the atomic weight is about 20 or double that figure. The following are the specific refractive energies of the elements with atomic weights between 12 and 23, with the insertion of argon. Carbon, 0·417; nitrogen, 0·236; oxygen, 0·194; fluorine, 0·03 (?); argon, 0·159; sodium, 0·209. Argon appears to be here in place on the rise which follows the great descent from carbon to fluorine. It does not equally well fit the neighbourhood of calcium, 0·250. If the atomic weight be 19·94, the molecular refraction will be 3·15, which is almost the same number as that for oxygen gas, 3·10, or nitrogen gas, 3·30.

(2) The fact that the specific refractive energies of the univalent metals are generally inversely as the square roots of their atomic weights is confirmed by further research, the product of the two being about 1·3. The same observation is now extended to the earthy metals in the second column of Mendeléeff's table, the products in that case being fully 1·4. The rule does not apply to the halogens in column 7. As to column 8, iron, palladium, platinum, and gold all give products

which are far higher. This confirms the belief that gold is not rightly placed in column 1.

(3) It is known that the refraction of a salt when dissolved in water is often slightly modified by the proportional amount of the solvent. The author and Mr. Hibbert have recently found that salts of the metallic elements in columns 1 and 2 of Mendeléeff's table show an increased refraction on dilution, those of metals in column 8 a diminished refraction.

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3. A Discussion 'On the Evidence to be Gathered as to the Simple or Compound character of a Gas, from the Constitution of its Spectrum,[1] was opened by Professor A. Schuster and Lord Rayleigh, and the following Papers were read:—

4. *The Constituents of Cleveite Gas.* *By* C. Runge *and* F. Paschen.

As the spectrum of the gas contains two sets of lines, each consisting of three 'series,' and no other lines, we may, according to the analogy of other spectra, draw the conclusion that it consists of two, and not more than two, elements. The yellow line D_3 belongs to the heavier of the two elements, which therefore should alone be called helium.

We have separated the two elements to a certain extent by a method of diffusion, the lighter constituent streaming more easily through a plug of asbestos. It was shown that the lines in the visible and in the ultra-red part of the spectrum ascribed to the heavier constituent are less intense relatively to the other lines the earlier the stream of the gas is cut off.

The same conclusion that the gas consists of two elements may also be drawn, first from the spectrum of the sun's limb, where the stronger lines of the heavier constituent are always present, while the stronger lines of the lighter constituent are only seen once in every four times. On the other hand in the spectrum of Nova Aurigæ at its first appearance we have the opposite case, the lines of the lighter constituent being far more prominent.

On Motions competent to produce Groups of Lines which have been observed in Actual Spectra. *By* G. Johnstone Stoney, *M.A., D.Sc., F.R.S.*

In most of the spectra that consist of lines very remarkable groups present themselves, in which the lines are seen to be associated into definite series. In such cases, except under special circumstances, we may safely presume that all the lines of a group arise from the motion of a single electron in every molecule of the gas.

Very striking examples of such groups are present in the absorption spectrum of oxygen and in the bright line spectrum of carbon. The oxygen of the earth's atmosphere produces the great A group of double lines in the solar spectrum, as well as the very similar great B group, and the *a* group. It also produces a group more refrangible than D, about which we know less. This group is much fainter than the others, and it is only under exceptional circumstances that it can be seen at all in the solar spectrum. Each of the other three groups can be distinguished into two sub-groups, which from their appearance have been called a head and a train. The general features of these three groups are the same, and Mr. Higgs has made a careful geometrical analysis of one of them, the great B group.[1] From his analysis we may infer that the head and the train are due to motions in the molecules which are distinct, although related to one another. This conclusion receives further support from the circumstance that in the double lines of 'the head' it is the violet component of each pair which is the stronger, while in the train it is the red component of each pair which is the stronger.

In a paper in the 'Scientific Transactions of the Royal Dublin Society' for 1891, p. 563, the present author pointed out that, if we proceed on the probable

[1] *Proc. Roy. Soc.*, 1893, p. 200.

supposition that the motion of each electron is an orbit of some kind going on within the molecules, it can be shown that the partials of the motion of the electron which causes the lines are elliptic partials, and that where an elliptic partial suffers an apsidal perturbation, it divides into two circular sub-partials, giving rise to the two constituents of a double line. We may infer from this that the sub-partials corresponding to the red constituents of the fourteen or more double lines of the train of B are circular motions revolving one way, and that all the violet constituents of these double lines result from circular motions revolving the other way.

In order to advance beyond this point it is necessary to make two further hypotheses which probably are both true. Two hypotheses must here be ventured upon because observations with the spectroscope give us no information as to the phases of the elliptic partials or the planes in which they lie. One hypothesis that recommends itself is that the circular sub-partials belonging to a connected series of double lines, *e.g.*, to the train of the great B group, lie in one plane. Another hypothesis which we may venture to make, as a preliminary working hypothesis, is that the amplitude of the motion of the electron has its maximum value at starting, *i.e.*, when that event has occurred at the close of a struggle between two molecules which has set up the motion of the electron, which continues during the comparative repose of the quiet, undisturbed journey in which the molecule is indulged after its encounter.

With these assumptions it is possible to synthesise all the motions causing the red constituents of the double lines into one motion, which is, however, not circular, but a slowly contracting spiral; and a similar resultant spiral motion turning the opposite way is furnished by the sub-partials forming the violet constituents. While these spirals are being traversed the radii or semi-amplitudes of the circular motions of which they are composed, and which correspond to the individual lines in the spectrum, may become shorter or longer owing to the escape of energy to the æther, or absorption of energy from it; so that the actual orbits are spirals which may be somewhat inside or somewhat outside those which result from the assumption that the radii retain their length. These two spiral motions combine at each instant into a single elliptic motion so elongated that it is nearly a linear vibration; and this elliptic motion continues to represent what occurs, if subjected to the five following perturbations :—

1. A decrease of amplitude.
2. A diminution of periodic time.
3. A slow apsidal motion in a direction opposite to that in which the revolution of the electron in the orbit takes place.
4. A slight fluttering motion which may be represented by a very shallow wave running rapidly round the ellipse.
5. A further slight modification of the form of the ellipse which takes the form of a secular perturbation.

Accordingly we arrive at the conclusion that *an elliptic motion undergoing these perturbations is such a motion of an electron as would produce the entire series of lines in the train of* B. A similar motion would produce the train of A, of *a*, and of each of the other similar groups, if such exist in the spectrum of oxygen. These elliptic motions undergoing perturbations may be appropriately called mega-partials in their relation to the actual orbit described in oxygen by the electron that produces all these trains of lines, since that orbit is the resultant which we should get by superposing the motions in these few mega-partials.

A similar treatment applied to 'the head' of any of the oxygen groups shows that it, too, arises from an elliptic motion subject to perturbations, the chief differences being in the law connecting the falling-off of amplitude and the periodic time; that the quick, fluttering perturbation is absent; and that the apsidal motion takes place in the opposite direction. In oxygen the strength of the lines of each sub-group fades out towards the red. When the fading is in this direction, the periodic time decreases as the amplitude falls off. Whereas when, as in the carbon spectrum, the lines fade out towards the violet, the periodic time becomes longer as the amplitude decreases. And, finally, if the lines present themselves, when plotted on a map of oscillation frequencies, as disposed symmetrically on either side of a common centre, this indicates that the periodic time continues unchanged during the shortening of the amplitude.

This suggests the cause of the width of spectral lines in general, so far as their width is not merely apparent, *i.e.*, due to the Doppler effect of the translational motions of the molecules, or to the breadth of the slit of the spectroscope. The rest of the width of the line, as seen, is its true physical width, and seems to be due to the interchange of energy between the molecule and the æther. This leads to diminished amplitude; and this reduction of the amplitude may be accompanied by either a reduction, or an increase, or a persistence unaltered of the periodic time, according to the way in which the motion of the electron is dynamically associated with the rest of the events which go on within the molecule. If the periodic time decreases, this gives rise to a ruling fading out towards the red; if there be an increase of the periodic time, the shading is towards the violet; while if the line fades out both ways symmetrically, there is no change in the periodic time. The relative intensities and the spacings of the lines of the ruling depend on the law which connects the escape of energy and the shortening of the semi-amplitude, and in its turn this law depends on the dynamical relations in which the parts of the molecule stand to one another. The excessively fine rulings of which the widths of individual lines consist can probably not be seen otherwise than as a shading, unless perhaps in some very few exceptional instances, owing to their being blurred together by the Doppler effect.

We have attributed these very fine rulings to the interchange of energy with the æther. On the other hand, the more conspicuous rulings, such as those we have been studying in oxygen and carbon, seem to be associated with the transference of energy from one motion within the molecule to another. This may be briefly described by saying that the widths of the individual lines and their being in various ways shaded off are due to radiation, while that they are arranged in series is due to conduction.

SATURDAY, SEPTEMBER 14.

The Section was divided into two Departments.

The following Papers and Reports were read:—

Department 1. MATHEMATICS.

1. *On the Translational and Vibrational Energies of Vibrators after Impacts on fixed Walls. By* Lord KELVIN, *Pres. R.S.*

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2. *On Bicyclic Vortex Aggregates. By* Professor W. M. HICKS, *F.R.S.*

The author showed that in any case of a vortex aggregate in which the motion takes place in planes through an axis, and symmetrical about this axis, another state of motion was possible with the same current and vortex sheets, but in which the motion was in circles round the axis, and in which the fluid external to the aggregate remained at rest. These two motions can be superposed with a resulting steady motion, and the two cyclic constants independent of each other.

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3. *On Hill's Spherical Vortex. By* Professor W. M. HICKS, *F.R.S.*

The author showed that it is possible to build up a compound spherical vortex, consisting of shells in which the rotation is oppositely directed in successive shells.

The vorticity and size of each shell must satisfy definite relations. When the vorticity of the fluid is everywhere of the same magnitude the ratio of the $(n+1)$th radius to the nth satisfies an algebraical relation of the form

$$4\lambda_n(x_n^2+x_n+1)=3x^3(x_n+1),$$

where $\lambda_n=1-\lambda_{n-1}(1-x^5_{n-1})$.

The ratio of the volumes of the shells for the first three are 1, 1·343, 1·341.

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4. *On a Dynamical Top.*[1] *By* G. T. Walker, *M.A.*

The author exhibited a top in the shape of a flattened ellipsoid with a central circular portion movable, and arranged so as to be clamped with the lines of curvature inclined to the axes of dynamical symmetry. In this condition a rotation communicated to the top when placed on a sheet of plate glass sets up oscillations which reverse the direction of motion: these reversals may, under favourable conditions, be as many in number as fifteen. A vertical tap administered at the end of an axis of symmetry gives rise to angular velocity, of which the sign depends on the difference between the periods of longitudinal and transverse vibrations, as well as on the angular deviation of the movable portion.

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5. *Suggestions as to Matter and Gravitation in Professor Hicks's Cellular Vortex Theory. By* C. V. Burton, *D.Sc.*

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6. *On the Graphical Representation of the Partition of Numbers. By* Major P. A. MacMahon, *F.R.S.*

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7. *On a New Canon Arithmeticus. By* Lt.-Col. Allan Cunningham, *R.E., Hon. Fell. King's Coll. Lond.*

This is a series of tables, drawn up precisely like Jacobi's 'Canon Arithmeticus,' giving the solution of the congruence $2^x \equiv R$ (mod. p and mod. m) for all prime moduli (p) $<1{,}000$, and also for all moduli $m<1{,}000$, where m is a power of a prime. There are two tables to each modulus, p or m. The left table shows the remainders (R) to a given index (x); the right table shows the index (x) to a given remainder (R).

Uses of Tables.

1. To find remainder R after dividing 2^x by p or m (x, p, m being given).
2. To find index x such that $2^x \div p$ or m may leave remainder R (R, p, m being given).
3. To find whether a given number N is exactly divisible by a given prime p, or power of prime m; and, if not, what remainder (R) is left.
4. To find whether a given number N is exactly divisible, or leaves a given remainder (R) after division, by any prime or power of a prime $<1{,}000$.
5. To find all the primitive roots of a given prime (p), and all the roots which are residues of a given order e of a given prime p, when 2 is a primitive root of p; and to find all the roots which are residues of a given order e of a given prime p when 2 is a residue of order not $>e$.

Jacobi's Canon gives the solution of $g^x \equiv R$ (mod. p and mod m) as above, except that g is a certain *primitive root* of p. His table is better for case 5 above whenever 2 is not a primitive root of p; but the new canon to base 2 is *much* more convenient for the more practical uses 2 and 3 above. His canon is well described in Cayley's Report on Mathematical Tables in the British Association Report of 1876: the description applies, with slight obvious modification, to the new canon.

[1] The paper will be published in the *Quarterly Journal of Mathematics.*

8. *On Mersenne's Numbers.*

By Lt.-Col. ALLAN CUNNINGHAM, *R.E., Hon. Fell. King's Coll. Lond.*

A Mersenne's number is one of form $N = (2^q - 1)$, where q is a *prime.* Divisors of these are difficult to discover. Their prime divisor (p), when N is composite, must be of form $p = 2eq + 1$, and also of one of forms $p = 8i \pm 1$, and 2 must be a residue of order e.

Simple rules (due to Legendre, Gauss,[1] and Jacobi,) are given for finding *directly* divisors (p)—when such exist—for the cases of $2e = 2, 6, 8, 16, 24$. An *indirect* method (due to Mr. C. E. Bickmore) is also given for the case when $p = 2ee'.q + 1$, where $2e$ has any of the above values, and $e' =$ an *odd* number > 3.

A table of divisors (p)—the greater part of which is believed to be original—is given: this is believed to be complete for all primes $p < 15{,}000$ for the simple cases of $2e = 2, 6, 8, 16, 24$. The following thirteen *new* instances were discovered by the indirect method quoted, and are the outcome of much labour.

p	q	$2e'$	p	q	$2e'$	p	q	$2ee'$
5,471	547	10	1,085,687	77,549	14	9,511	317	30
14,831	1,483	10	650,359	36,131	18	28,111	937	30
33,191	3,319	10	4,438,919	201,769	22	7,487	197	38
1,320,191	132,019	10	214,007	8,231	26	18,199	337	54
						172,681	1,439	120

One of these, viz. $(2^{197} - 1)$, is among those stated by Mersenne in 1,664, but without proof, to be composite; proof of this is now supplied in the discovery of a divisor ($p = 7{,}487$).

Nineteen of the Mersenne's numbers stated by Mersenne to be *composite* (viz., when $q = 71, 89, 101, 103, 107, 109, 137, 139, 149, 157, 163, 167, 173, 181, 193, 199, 227, 229, 241$), and three of those stated by him to be *prime* (viz., when $q = 67, 127, 257$), remain *still unverified.* The author has tried all prime numbers $< 50{,}000$ without finding a divisor for any of them.

There are only ten *prime* Mersenne's numbers known, viz., when $q = 1, 2, 3, 5, 7, 13, 17, 19, 31, 61$; the establishment of any more is very difficult. It is worth noting that these ten values of q, as also three more ($q = 67, 127, 257$) conjectured by Mersenne to yield prime values of N, all fall under one of the *four* forms $q = 2^x \pm 1$, or $2^x \pm 3$; but it is not true that such values of q necessarily make N prime.

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9. *Recent Developments of the Lunar Theory.* *By* P. H. COWELL, *M.A.*

Kepler discovered that the motion of planets about the sun and the moon about the earth took place approximately in ellipses, and Newton showed that motion in an ellipse according to Kepler's well-known laws was the consequence of the law of gravitation.

For nearly two centuries after Newton, the lunar theorists based their investigations of the moon's motion upon Newton's discovery. Their reason for doing this was that the elliptic inequality is by far the largest of all the lunar inequalities. The other inequalities were then calculated as disturbances due to the sun. One modification had, however, to be made. In order to agree with observations, displacements increasing with the time had to be assigned to the apse and node. The orbit thus modified no longer satisfied the undisturbed equations of motion, and the velocities of the node and apse, as well as the remaining inequalities, had to be found—in most theories—by continued approximation.

In performing the algebraical calculations, however, it appeared that the terms constituting the inequality known as the variation had first to be calculated, and

[1] The author is indebted to Mr. C. E. Bickmore for the communication of these rules.

that subsequently the terms containing powers and products of the eccentricities, inclination, and ratio of the parallaxes could be calculated in turn, the lower orders being taken first. This point must have presented itself to Laplace and Pontécoulant in their respective theories; but it is brought out more clearly in those treatises where the object is not to obtain a complete analytical development, but to exhibit the method of procedure. In Delaunay's theory this point does not present itself, but by modifying Delaunay's theory so as to reduce the number of variables from six to two the variational terms might be calculated independently, whereas by no process could the other terms be calculated before the variational terms.

These considerations point to the curve indicated by the variational terms being treated as the intermediary orbit in preference to the ellipse; but it was not till the year 1877 that this idea was developed. Dr. G. W. Hill then published three papers in the first volume of the 'American Journal,' papers which Poincaré describes as containing the germ of the greater part of the progress that astronomy has since made.

Relatively to the sun's mean place the variation terms define a closed curve which the moon under suitable initial conditions could describe, if the sun's parallax and eccentricity were zero. The curve is symmetrical in all four quadrants, and remains symmetrical about the line of syzygies, when the sun's parallax is taken into account. Dr. Hill has drawn the variation curve for different ratios of the month to the year. The curve for small values of this ratio does not differ much from a circle, but is slightly elongated in quadrature. This elongation increases with the length of the month, and when there are only 1·78265 months to the year the curve has cusps on the line of quadratures. Such an orbit must certainly be unstable, and by a discussion of Jacobi's equation of relative energy Dr. Hill makes it appear probable that instability sets in for a much smaller value of the ratio. No numerical limit has, however, been obtained for stability. M. Poincaré has succeeded in obtaining the general shape of these curves when continued beyond the cusped curve. The orbit first crosses the line of quadratures obliquely, and then recrosses at a greater distance at right angles, then returns to the first intersection, thus forming a loop, and ultimately forms a closed curve with two loops, six intersections with the line of quadratures and two with that of syzygies. Dr. Hill has also calculated algebraically and numerically and with extreme accuracy the coefficients of the different periodic terms that define the variation curve.

In the older lunar theories the physical meaning of the quantity that in undisturbed motion denoted the eccentricity disappeared upon the introduction of the disturbance with the ellipse upon which it depended for its definition. At the conclusion of the theories it was defined analytically by equating a given function of it to the coefficient of one of the periodic terms. Such a definition is merely analytical, and has no physical interpretation. The quantity, in fact, is a mere constant of integration. It is not even correct to say that it reduces to the eccentricity when the sun's mean motion is put zero. The eccentricity of the ellipse obtained by putting the sun's mean motion zero is a function of the constants of integration and of the position of the sun's apse, and of the sun's parallax. By Dr. Hill's investigations, however, a physical meaning is restored. It is a parameter defining the amplitude of the oscillation that takes place about that state of steady motion relatively to the sun that Dr. Hill has shown can take place, provided only the sun's eccentricity be negligible. With the notion of eccentricity, the notion of the apse of the older theories becomes indistinct. The so-called apse is certainly not a point where the moon is moving at right angles to its radius vector. According to Dr. Hill's theory, the period of revolution with respect to the apse now becomes the period of the oscillation about steady motion. In like manner the inclination of the orbit may be considered as another oscillation about steady motion, the inclination constant of integration defines its amplitude, and the period of revolution with respect to the node, which is not accurately the point of intersection with the ecliptic, is now the period of this second oscillation. In accordance with the general theory of small oscillations, the two modes of oscillation can co-exist in complete independence so long as the squares of the amplitudes are negligible. The two periods in such a case depend only on the circumstances of steady motion, in this case on the ratio of the month to the year. The periods in the actual case, however, must be corrected by terms depending on squares and higher powers of the sun's eccentricity and the two parameters defining the amplitudes.

In a paper in the 'Acta Mathematica,' vol. viii., Dr. Hill finds the period of a small oscillation of the first of the two kinds mentioned. His method involves the consideration of an infinite determinant. He states that there can hardly be a doubt that the determinant is convergent, but M. Poincaré has submitted the question to a rigid investigation.[1] He concludes that an infinite determinant, when the constituents of the leading diagonal are all unity, converges absolutely and uniformly if the sum of all the other elements is finite. Any determinant can be reduced so that the elements of the leading diagonal are all unity, provided that the product of these elements is finite. Dr. Hill's determinant satisfies these conditions when the length of the month is sufficiently small. To complete the proof it is necessary to notice that M. Poincaré, in his 'Mécanique Céleste,' proves that the series defining Dr. Hill's variation curve converge for sufficiently small values of the length of the month.

At the conclusion of his paper, Dr. Hill solved his infinite determinantal equation, and obtained the principal part of the motion of the apse with great arithmetical accuracy. The value he obtains differs in the fourth significant figure from that calculated from Delaunay's series; it also agrees well with the observed value, thus verifying a prediction of Delaunay's, as far as the apse is concerned, that the remainder of his series would bring calculation into agreement with observation. Dr. Hill has lately calculated an algebraic value to eleven terms for the principal part of the motion of the perigee. He concludes by replacing the ratio of the month to the year by another parameter, empirically determined so as to increase the convergence of the last terms calculated. This last step, however, does not appear to be in any degree useful, as the convergency of the series near its tenth term throws no light on the convergency of the remainder.

The question of convergency of the series obtained in the lunar theory had hardly been investigated before Poincaré and Lindstedt. Formal solutions to the seventh order and arithmetical solutions have been obtained, but it cannot be assumed from the close agreement of the two that the coefficients can be represented by the algebraic series. Poincaré has shown, however, that in certain cases periodic solutions must exist, and as a special case the series for the coefficients of the variational terms must converge for sufficiently small values of the ratio of the month to the year. The motion of the node, so far as it depends on the ratio of the mean motions only, had been investigated by Adams before Dr. Hill's work on the perigee was published. Adams also obtained an infinite determinant. In the arithmetical work, however, he used a different value of the ratio of the mean motions to that used by Delaunay and by Dr. Hill. It is an illustration of the almost unnecessary accuracy of the numerical work that it should have been carried to fifteen decimal places, whereas the ratio of the mean motions, certainly by far the easiest quantity to determine by observation, can only be depended upon to seven places. I have recomputed the principal part of the motion of the node using Dr. Hill's numbers. It may be noticed that the arithmetical value in this case does not, as in the case of the perigee, justify Delaunay's prediction that the remainder of his series would account for the discrepancy between theory and observation.

Dr. Hill's method of procedure is to use rectangular co-ordinates, the axes of reference rotating round the ecliptic with a velocity equal to the sun's mean motion. The calculation of the variation terms by this method is perhaps not so short as it would be by some other method—possibly the best way to obtain them would be by Delaunay's methods, the variables being reduced to two—but undoubtedly no theory is so simple for the calculation of the higher inequalities. For each new set of coefficients the problem can be quickly reduced to the solution of a system of linear simultaneous equations. The principal parts of the motions of the perigee and node are given by infinite determinants: the further approximations appear as

[1] *Bulletin de la Société Mathématique de France,* xiv. pp. 77–90.

additional unknown quantities to be determined by the simultaneous linear equations. The solution has to proceed by continued approximation, and is exceedingly laborious. In an admirable paper in the current number of the American Journal, Prof. E. W. Brown has shown how the new part of the motion of the perigee and node can in all cases be evolved from the terms previously calculated. This consideration not only shortens very considerably the labour of the continued approximations, but it enables us to regard one of the simultaneous equations as an equation of verification. Professor Brown's paper—undoubtedly the most valuable of all the papers that are based upon Dr. Hill's researches—concludes with some extensions of Adams's theorems connecting the mean value of the parallax with the motions of the node and perigee. These extensions possess an analytical interest, but as applied to the development of a solution of the problem of three bodies in series, they only provide some equations of verification of a value far inferior to those investigated in the earlier part of his paper.

The following advances have been made towards a complete development of the problem of three bodies. Dr. Hill calculated the variation terms; Professor Brown the terms depending on the ratio of the parallaxes, the terms depending on the first, and subsequently the second and third powers of the moon's eccentricity; also the terms depending on the first power of the sun's eccentricity, and also the product terms containing the first powers of both the eccentricities. These latter are the only product terms hitherto calculated by Dr. Hill's methods. The convergence of the series Delaunay obtains in his literal development is exceedingly slow, and the arithmetical values show a residue in some of Delaunay's series of over one second. I have calculated terms depending on the first three powers of the inclination. Besides this, Dr. Hill has obtained the principal part of the motion of the perigee, and Adams the principal part of the motion of the node. Professor Brown has calculated the correction to the motion of the perigee depending on the square of the eccentricity, and I have calculated the correction to the motion of the node depending on the square of the inclination.

At the beginning of his last paper, referred to above, Professor Brown has collected the bibliography of the subject.

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10. *The Relation between the Morphological Symmetry and the Optical Symmetry of Crystals.* *By* William Barlow.

Starting from the well-known facts of the influence of the presence of molecular matter generally on the velocity of light, and of the directional optical properties of crystals, the author reaches the conclusion that ether-movements which take place in the same crystal in different directions experience different degrees of resistance and retardation, so that a state of things prevails roughly comparable to what would happen if a space occupied by a crowd of people were studded with posts arranged on parallel lines and evenly distributed; the movements of the crowd as it surged to and fro would be less impeded in some directions than in others, especially if the posts were not round, but of similar section sameways orientated. In the case of both the ether and the crowd what are compared are the collective resistances in each direction, differences in the retardation experienced by different particles or persons moving side by side in the same direction not being discriminated.

Even if the crystal employed belongs to the cubic system, and is therefore isotropic, the ether-movements must, as in the case of less symmetrical crystals, experience different retardation in different directions; and the necessary deduction from this is that if the influence of a homogeneous molecular structure on light depends on *the arrangement* of the molecular matter, *it is an average effect*, the velocity of a ray in any given direction depending, not merely on the resistance to ether-movement experienced *in some single direction* definitely related to the direction of polarisation of the ray, *but on that experienced in a number of different directions inclined to one another.* The writer cites in support of this conclusion the fact that in crystals belonging to the less symmetrical crystal systems, in which a change of velocity accompanies any continuous change of direction, this change of velocity is always *a very smooth one*, and not abrupt.

After remarking that if the velocity of a ray in any given direction were dependent *equally* on the resistances offered to ether-movement in *every* direction, this velocity would in all cases be entirely independent of any particular direction or directions in the structure, which would in all cases be isotropic, he says that the experimental facts show that the truth lies between the two extremes indicated; that the velocity of a ray depends neither on all the resistances to ether-movement experienced in all directions taken equally, nor on the resistance experienced in a single solitary direction, but depends *equally, or almost equally, on the resistances afforded in all the directions included within some wide limits of angular inclination,* this being the only kind of relation which would be in harmony with the great smoothness of the change of velocity presented when a continuous change of direction is made.

He then suggests that the simplest sort of relation which the velocity can be conceived to bear to the resistances offered by the structure to ether-movement is for the resistance whose direction is that of the polarisation of the ray—*i.e.*, the direction in which the algebraically deduced wave-vibration takes place—to exert a maximum influence, and the effect of the resistances in directions inclined to this to diminish as the inclination increases, the decrement of influence for directions near the direction which furnishes the maximum effect being, however, very small indeed.

He points out that if this simple kind of relation obtains, *the velocity figure*—*i.e.*, the figure whose radii express the different velocities proper to different directions of polarisation for rays traversing a crystal—must exhibit a smoothed curvature derived indeed, but having a very different aspect, from that of the corrugated surface whose radii would express the relative facility of ether-movement taking place in different directions in the same crystal; and that the simplest conceivable result of such a smoothing or averaging will be for the velocity-figure to approximate as closely as we please to the result obtained by treating the velocity appropriate to any direction of polarisation whatever as the resultant of three components acting in some particular three widely separated directions, each component, in harmony with the averaging referred to above, being greater or less as the direction of the resultant which is being resolved lies nearer to or further from its direction, and being zero when the resultant lies in the plane of the remaining two components. The relative lie of the three directions will, of course, depend on the nature of the crystal structure. The reason for taking *three* directions is that this is the least number which can be employed consistently with generality.

He proceeds to show that the simplest figure thus obtainable is an ellipsoid, of which the three axes are conjugate diameters, and calls attention to the fact that the number of the sets of three axes which will fulfil the requisite conditions in any given case is unlimited.

From the fact that the velocity-figure is in all crystals found to be an ellipsoid (specialised, indeed, in some of the crystal systems), he finally argues that *the velocity of a ray is an average effect of the different resistances to ether-movement offered in different directions of the nature above explained;* and that the combination or averaging by which so simple a figure as the ellipsoid is reached *must not only extend over a wide range of resistances for each velocity, but also that it must be so nearly uniform in its application throughout some considerable portion of this range as to preclude entirely all merely local effects of the structural features of the crystal on the contour of the velocity-figure.*

In closing, the writer remarks that the directions which give maximum or minimum velocity—*i.e.*, those of the principal axes of the ellipsoid—will not necessarily be directions of maximum or minimum facility of ether-movement, the indents and protuberances of the corrugated figure whose radii express the relative facility of ether-movement in different directions not being traceable as such on the velocity-figure.

Also that the directions of the principal axes of the velocity-ellipsoid will not be ascertainable from the morphological constants unless the degrees of resistance presented in different directions are known; except, however, the cases of the more symmetrical systems in which the positions of these axes are fixed by symmetrical considerations.

A similar observation applies to the absorption-figure for monochromatic light, which is also an ellipsoid.

The fact that the *elasticity-figure* of crystals is a surface of a higher order than an ellipsoid is due to its being the outcome of a compounding and averaging whose scope is more limited and not so uniform as that above referred to.

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11. *On a Species of Tetrahedron the Volume of any member of which can be determined without employing the proof of the proposition that Tetrahedra on equal bases and having equal altitudes are equal, which depends on the Method of Limits. By* M. J. M. Hill, *M.A., D.Sc., F.R.S., Professor of Mathematics at University College, London.*

The object of this communication is to prove the existence of the species of the tetrahedron mentioned in the title.

Art. 1. A proof is first given of the known proposition, that if the edges B A, C A, D A of the tetrahedron A B C D be produced through A to E, F, G respectively, so that B A = A E, C A = A F, D A = A G, then the tetrahedra A B C D, A E F G are of equal volume.

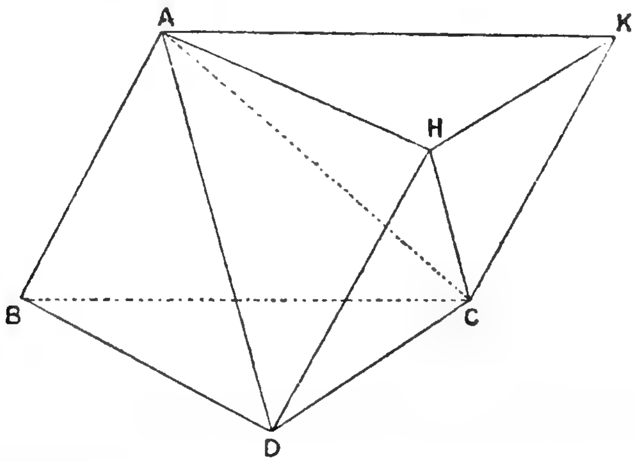
Art. 2. From the above proposition it is deduced that if the edge D A of the tetrahedron A B C D be perpendicular to the plane A B C, and if D A be produced to E, so that D A = A E, then the tetrahedra A B C D, A B C E are of equal volume.

Art. 3. Now let A B C D be a tetrahedron, and let D H, C K be drawn equal and parallel to B A.

Join H A, A K, K H, H C.

Then if B H be perpendicular to the plane A C D, it follows, by applying Art. 2 twice over, that the tetrahedra A B C D, A D C H are of equal volume.

In like manner if D K be perpendicular to the plane A C H, it follows that the tetrahedra A D C H, A H C K are of equal volume.



Hence the tetrahedron A B C D is one third of the prism, having the same base and altitude.

The two conditions—

(1) That B H is perpendicular to the plane A C D, and (2) that D K is perpen-

dicular to the plane A C H—result in the expression of the lengths of the six edges of the tetrahedron in terms of two positive quantities a, k as follows:—

$$AC = a\sqrt{9-3k^2};$$
$$AD = BC = 2a;$$
$$AB = BD = DC = a\sqrt{1+k^2}.$$

Hence $o < k < \sqrt{3}$.

The faces B D A, B D C are equal isosceles triangles.

The faces A C B, A C D are equal scalene triangles.

The planes B C A, B C D are perpendicular to each other, and so are the planes A D B, A D C.

The planes A C B, A C D are inclined at an angle of 60°.

The planes A B C, A B D are inclined at the acute angle whose cosine is $\frac{1}{2}\sqrt{3-k^2}$, and so are the planes C D A, C D B.

The planes B D A, B D C are inclined at the angle whose cosine is $\frac{1}{2}(k^2-1)$, which is obtuse if $o<k<1$, but acute if $1<k<\sqrt{3}$.

The volume of the tetrahedron is $\frac{1}{3}a^3k^2\sqrt{3-k^2}$.

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12. *On Absolute and Relative Motion.* *By* Prof. J. D. Everett, *F.R.S.*

Though there is no test by which we can distinguish between absolute rest and uniform velocity of translation, D'Alembert's principle furnishes a test by which deviation from such uniformity can be detected. Every deviation produces the same effects which would be produced by bodily forces opposite to the actual changes of velocity. The intensity of the apparent bodily force is equal in each case to the absolute acceleration.

What is called centrifugal force is an apparent bodily force directed outwards from the centre of curvature of the body's path, and having an intensity equal to the distance from this centre, multiplied by the square of the absolute angular velocity. Angular velocity, unlike velocity of translation, involves acceleration; and by comparing the accelerations of different points of a rigid body we can measure the absolute angular velocity of the body. The slope of a conical pendulum and the concavity of the surface of the liquid in a revolving vessel are phenomena which depend on absolute velocity of horizontal rotation; and another measure of horizontal angular velocity is furnished by differences of pressure at different points in a horizontal tube full of liquid.

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13. *On the Magnetic Field due to a Current in a Solenoid.* *By* W. H. Everett, *B.A.*

The case of a solenoid of circular section is the only one hitherto investigated, and this has been done by considerations derived from magnetic shells. In this paper the problem is approached by a more direct method, and general solutions are obtained in a form which can be readily worked out to numerical values. Special application is made to the case of a rectangular (or polygonal) solenoid, the component forces being expressed in finite terms. For a very long solenoid of any form of section the longitudinal force in either of the end sections is shown to be exactly the same at all points, and in any solenoid the longitudinal force is shown to be more uniform in the end sections than in the medial section. As a particular case the method gives the component forces due to a plane circuit at any point in its field; and a simple expression is found for the force, at any interior point, due to a circular current.

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14. *On the Law of Error in the Case of Correlated Variations.* *By* S. H. Burbury, *F.R.S.*

If we have a great number, N, of independent magnitudes, each liable to variation according to any law of its own, but remaining always finite, the chance that their sum, each divided by $\sqrt{N}$, shall lie between x and $x+dx$ is proportional to $\epsilon^{-hx^2}dx$, where h is a constant. The proof of that proposition is originally due to Poisson. The first application of it was to errors of observation, each of the 'magnitudes' aforesaid being such an error, and the N observations being supposed independent.

Modern writers, among others Mr. F. Galton and Mr. F. Y. Edgeworth, have substituted for the single magnitude given by each independent observation a group of mutually dependent or 'correlated' magnitudes, and for the single square forming the index in ϵ^{-hx^2} a quadratic function, *i.e.*, sums of square and products of the correlated magnitudes. If, for instance, they be denoted by x and y, the expression corresponding to $\epsilon^{-hx^2}dx$ will be $\epsilon^{-(ax^2+bxy+cy^2)}dxdy$. The coefficient b expresses the fact of 'correlation' between x and y.

The object of the following paper is (1) to extend the purely mathematical investigation hitherto applied to the case of single magnitudes to the case of groups of magnitudes, the members of each group, although 'correlated' with one another, being still supposed independent of any other group—in this I only follow the lines of the known proof; and (2) to show how in certain cases the method may be extended to groups which do not possess this property of mutual independence.

Part I.—Articles 1–15.

1. Let $f_a(a_1 \ldots a_n)$, or f_a, be a continuous function of the variables $a_1 \ldots a_n$. Let $f_b(b_1 \ldots b_n)$, or f, be the same or a different function of the variables $b_1 \ldots b_n$, and so on to $f_q(q_1 \ldots q_n)$, there being N functions. Denote by P_a the integral

$$\iint_{-\infty}^{\infty} \ldots f_a\, da_1 \ldots da_n,$$

and by P_b

$$\iint_{-\infty}^{\infty} \ldots f_b\, db_1 \ldots db_n, \text{ \&c.}$$

2. Assume the b's to be independent of the a's, so that the variables a are not contained explicitly or implicitly in $f_b \ldots$ or f_q, the variables b are not contained in f_a, or in $f_c \ldots f_q$, and so on. Then

$$P_aP_b \ldots P_q = \iint \ldots f_af_b \ldots f_q da_1 \ldots dq_n.$$

3. Of the N_n variables, $a_1 \ldots q_n$ form now n linear functions whose type is

$$\lambda_1a_1 + \lambda_2b_1 + \ldots$$
$$\mu_1a_1 + \mu_2b_1 + \ldots$$

where the coefficients are numerical and of the order of magnitude $\frac{1}{\sqrt{N}}$. Let it be required to find the value of

$$\iint \ldots f_af_b \ldots f_q da_1 \ldots dq_n,$$

subject to the condition that the linear functions lie respectively between limits $s_1 + \ldots s_1 + ds_1$, &c.

4. To do that, substitute $s_1 \dots s_n$ for $a_1 \dots a_n$ by the linear equations, and then perform the integration according to b c, &c. That reduces the integral to $\phi(s_1 \dots s_n)ds_1 \dots ds_n$, where ϕ denotes some function.

Now let

$$X_a = \iint \dots f_a \epsilon^{(\lambda_1 a_1 \theta_1 + \mu_1 a_2 \theta_2 + \dots)\sqrt{-1}} da_1 \dots da_n,$$

$$X_b = \iint \dots f_b \epsilon^{(\lambda_2 b_1 \theta_1 + \mu_2 b_2 \theta_2 + \dots)\sqrt{-1}} db_1 \dots db_n, \text{ \&c.}$$

That gives

$$X_a X_b \dots X_q = \iint \dots \phi(s_1 \dots s_n) \epsilon^{(s_1\theta_1 + s_2\theta_2 + \dots \sqrt{-1}} ds_1 \dots ds_n.$$

5. It is now proved (Prop. I.) that

$$\phi(r_1 \dots r_n) = \iint_{-\infty}^{+\infty} \dots d\theta_1 \dots d\theta_n X_a X_b \dots X_q \epsilon^{-(r_1\theta_1 + \dots + r_n\theta_n)\sqrt{-1}}$$

multiplied by a constant independent of $r_1 \dots r_n$.

6. Proposition II. is next proved, that if

$$\int du_1 \int du_2 \dots f(u_1 \dots u_n) \cos(\theta_1 u_1 + \theta_2 u_2 + \dots) = \rho \cos r,$$

and

$$\int du_1 \int du_2 \dots f(u_1 \dots u_n) \sin(\theta_1 u_1 + \theta_2 u_2 + \dots) = \rho \sin r.$$

And if at the same time

$$\int du_1 \int du_2 \dots f(u_1 \dots u_n) = 1,$$

Then if $\theta_1 = \theta_2 = \dots = \theta_n = 0$, $\rho = 1$. If any $\theta \neq 0$, $\rho < 1$.

From this it follows that unless every $\theta = 0$, each of the quantities $X_a, X_b \dots X_q$ is less than unity.

7. Now let $a_1 \dots a_n$ be any set of correlated variables, and let $f_a(a_1 \dots a_n) da_1 \dots da_n$ be the chance that they shall simultaneously lie between the limits $a_1 \dots a_1 + da_1$, &c. Let $f_b(b_1 \dots b_n)$ have the corresponding meaning for another set of correlated variables independent of the a's, and so on for f_c, &c.

Then, if we form the linear functions

$$\lambda_1 a_1 + \lambda_2 b_1 + \text{\&c.}$$
$$\mu_1 a_1 + \mu_2 b_1 + \text{\&c.},$$

the chance that they shall lie between the limits r_1 and $r_1 + dr_1$ &c. is, by Proposition I.,

$$\int_{-\infty}^{\infty} d\theta_1 \dots \int_{-\infty}^{\infty} d\theta_n X_a X_b \dots X_q \epsilon^{-(r_1\theta_1 + \dots + r_n\theta_n)\sqrt{-1}}$$

multiplied by a constant independent of $r_1 \dots r_n$.

8. In this expansion substitute for X_a &c. their values, and expand the exponential factor.

If any θ differs from zero, each of the factors X is, by Prop. II., less than unity, and therefore (since we are dealing not with the product of integrals, but with the integral of the product $X_a \dots X_q$) we may neglect in that expansion all powers of θ above the second. The expansion is then reduced to the form

$$\iint \dots \epsilon^{-R} d\theta_1 \dots d\theta_n,$$

in which

$$R = A_1\theta_1^2 + B_{12}\theta_1\theta_2 + \text{ \&c. } - (r_1\theta_1 + \ .\ .\ .\ + r_n\theta_n)\sqrt{-1},$$

in which A_1 B_{12}, &c., are known.

And performing the integrations according to $\theta_1 \ .\ .\ .\ \theta_n$, we obtain as result the expression

$$\epsilon^{-(a_1(r_1-\bar{r}_1)^2 + b_{12}(r_1-\bar{r}_1)(r_2-\bar{r}_2) + \text{ \&c.}},$$

in which the coefficients are known quantities when the functions f_a, f_b, &c., and the λ's, μ's, &c., are known.

It thus appears that the chance of the linear functions

$$\lambda_1 a_1 + \lambda_2 a_2 + \ .\ .\ .$$
$$\mu_1 b_1 + \mu_2 b_2 + \ .\ .\ .$$

lying respectively within the limits

$$r_1 \ .\ .\ .\ r_1 + dr_1,$$
$$r_2 \ .\ .\ .\ r_2 + dr_2, \text{ \&c.},$$

is a quadratic function of $(r_1 - \bar{r}_1)$, $(r_1 - \bar{r}_2)$, &c. The exponential form always occurs in the result, whatever be the forms of the functions f_a, f_b, &c. Only the coefficients of the quadratic function are determined by the forms of these functions.

Part II.

9. Up to this point we have assumed that any one of our sets of correlated variables, e.g. $a_1 \ .\ .\ .\ a_n$, or, as we may call it, any one 'association,' is independent of the variables in any other.

It is now proposed to treat the several associations $a_1 \ .\ .\ .\ a_n$, $b_1 \ .\ .\ .\ b_n$, &c., as representing the state of the same material system, defined by n variables, at successive points of time. That is, if $x_1 \ .\ .\ .\ x_n$ be the variables defining the system, $f_a da_1 \ .\ .\ .\ da_n$ is the chance that when $t=0$ they shall lie within the limits

$$x_1 = a_1 \text{ and } x_1 = a_1 + da_1, \text{ \&c.}$$
$$x_2 = a_2 \text{ and } x_2 = a_2 + da_2, \text{ \&c.}$$

Similarly $f_b db_1 \ .\ .\ .\ db_n$ is the chance that when $t=\tau$ they shall lie within the limit $x_1 = b_1$ and $x_1 = b_1 + db_1$, &c., and so on. Then generally the variables $b_1 \ .\ .\ .\ b_n$ are not independent of $a_1 \ .\ .\ .\ a_n$, because given that when $t=0$, $x_1 = a_1$, &c., that affects the chance that when $t=\tau$, x_1 shall $= b_1$, &c.

We cannot therefore at once apply our investigation of Part I. to the series of functions f_a, f_b, &c.

10. It is now shown that in cases where the condition of complete independence is not satisfied, another condition, called the *modified condition of independence*, may be satisfied. That is, namely, that although the b's are not independent of the a's for such values of the time τ, yet it may be the case that when $\tau =$ or $>$T, where T is a definite time, the b's are independent of the a's, or $\dfrac{df_b}{da}$ vanishes. It is shown that if that modified condition be satisfied for every pair of associations, or states of the system, separated by an interval of time not less than T, we may legitimately apply the method of Part I. to the whole series of associations, N^2 in number, at intervals of time δt or $\dfrac{T}{N}$, exactly as if they were mutually independent. If, that is, we form n linear functions of the type

$$\lambda_1 a_1 + \lambda_2(a_1 + \delta a_1) + \ .\ .\ .$$
$$\mu_1 a_2 + \mu_2(a_2 + \delta a_2) + \ .\ .\ .$$

and find the chance that they shall respectively lie within the limits $r_1 \ .\ .\ .\ r_1 + dr_1$, &c., by the method of Part I. we obtain correct results so far as the exponential form is concerned. The result is of the form $\epsilon^{-R} dr_1 \ .\ .\ .\ dr_n$, with R a quadratic function of $(r_1 - \bar{r}_1)$, $(r_2 - r_2)$, &c.

11. We may now make our variables $x_1 \ldots x_n$, the time differentials of another set $\xi_1 \ldots \xi_n$, that is,

$$x_1 = \frac{d\xi_1}{dt}, \qquad x_2 = \frac{d\xi_2}{dt}, \text{ \&c.}$$

And $f(a_1 \ldots a_n)da_1 \ldots da_n$ is now the chance that when $t=0$

$$\frac{d\xi_1}{dt} = a_1 \ldots a_1 + da_1,$$
$$\frac{d\xi_2}{dt} = a_2 \ldots a_2 + da_2, \text{ \&c.,}$$

and we now use for our linear functions

$$\lambda_1 a_1 + \lambda_2(a_1 + \delta a_1) + \ldots = \delta t \Sigma \frac{d\xi_1}{dt},$$

the summation including all the successive values of $\frac{d\xi_1}{dt}$ at the successive times $t=0$, $t=\delta t$, $t=2\delta t$, &c. Similarly, for the second linear function we take $\delta t \Sigma \frac{d\xi_2}{dt}$, and so on.

12. Then we may make δt infinitely small and N infinitely great, while $N\delta t = T$ and our linear functions become

$$\int_0^T \frac{d\xi_1}{dt}\delta t, \qquad \int_0^T \frac{d\xi_2}{dt}\delta t, \text{ \&c.,}$$

or $\xi_1 - X_1$, $\xi_2 - X_2$, &c., if X_1, X_2, &c., now denote the initial values of ξ_1, ξ_2, &c. And our proposition now assumes the form that the chance of $\xi_1 \ldots \xi_n$ lying within assigned limits varies as

$$\frac{T}{\epsilon}\left\{ (a_1(\xi_1 - X_1)^2 + b_{12}(\xi_1 - X)(\xi_2 - X_2), \text{ \&c.}) \right\},$$

where the index is a quadratic function of $(\xi_1 - X_1)$, $(\xi_2 - X_2)$, &c.

We thus get the exponential form, or 'law of error,' in all cases for which the modified condition of independence is satisfied. In order that it may be satisfied the time variation of $\xi_1 \ldots \xi_n$ must depend not only on the values of $\xi_1 \ldots \xi_n$ for the time being, but also, in some appreciable degree, on external fortuitous causes. And the greater the comparative importance of these fortuitous causes, the shorter is the time T which, as the interval between two successive states of the system, makes the variables in one of those states independent of those in the other.

Department II. Meteorology.

1. *Probable Projection Lightning Flashes.*
By Eric Stuart Bruce, *M.A. Oxon., F.R.Met.Soc.*

The classification of lightning flashes is already beset with difficulties. The object of this paper is to suggest the possibility of Projection Lightning Flashes, the existence of which would increase the difficulties of classification.

Sheet lightning reflected on clouds is made up of numerous images of the lightning flash superimposed one upon the other. If there is a cloud with a sufficiently small opening in it between the lightning discharge and a reflecting surface of clouds, the latter being in an adequate position, on the clouds that otherwise would have been merely illuminated with sheet lightning will appear the optical projection of a lightning flash. If the surface of clouds upon which the image falls is level, the image will be a perfect reproduction of the lightning flash, save that it is inverted, and to some extent dulled in brilliancy. If, however, the surface of the clouds is irregular, such as those of the cumulus type, the image of the flash will take the shape of the irregular surface. In this way a zig-zagged flash with long angles could be formed very like the lightning flashes depicted by artists.

If there happen to be more openings than one in the clouds between the flash and receiving surface, there will be a corresponding reduplication of the flashes, which may perhaps explain some of the multiple effects observed.

If projection flashes occur in nature it becomes a question whether the photographic plate can register them.

2. *Report on Solar Radiation.*—See Reports, p. 81.

3. *Report on Earth Tremors.*—See Reports, p. 184

4. *Reports on Earthquakes in Japan.*—See Reports, pp. 81, 113.

5. *On some Experiments made with Lord Kelvin's Portable Electrometer. By* ARTHUR SCHUSTER, *F.R.S.*

Experiments made during a recent trip to Switzerland have demonstrated the great convenience of Lord Kelvin's portable instrument for the observation of atmospheric electricity. The electrometer can easily be carried in a knapsack to almost any place the mountaineer can reach, and the observations are readily performed in a short space of time. The object of the experiments was to learn, if possible, whether the electric force at great heights is sensibly different from that at the sea-level. But owing to the difficulty of comparing together observations made in valleys with those made on mountain peaks, the measurements made during the past year were entirely of a tentative character, more for the purpose of testing the working of the instrument than of obtaining any definite results. The numbers given are only relative, and are referred to an arbitrary unit.

Numerous experiments made in fine weather in the centre of a small meadow in front of the hotel at Pontresina gave for the electric force, on the average, about 30, while the number obtained on September 13, in Ipswich, in a place rather more sheltered by surrounding houses, was between 80 and 100.[1]

On the so-called 'Diavolezza Pass' the force was as high as 147; on the Isola Pers, a rocky island, projecting well out of the surrounding glaciers, the number found was 116. The instrument was taken on August 19 to the top of the Glüscheint (12,000 feet), which consists of a ridge of rocks just wide enough for one man to stand upon. The electric force reached the number 816, while on the snow-field a few hundred feet below the top, the force was only 170. The top of the Schafberg gave 357.

On the Morteratsch glacier the numbers were, as a rule, very low, except on one occasion, when a strong downward wind was blowing; even then the force was only 42. Half a mile below the foot of the glacier, the numbers were very irregular, and seemed to depend a good deal on the direction of the wind. On one occasion, when that direction was frequently changing, a negative electrification was observed whenever the current of air was away from the glacier. This may have been due to the negative electrification caused by the glacier stream in a way similar to that in which a similar electrification is produced by a waterfall.

The diurnal variation was observed on one day by taking measurements every half-hour during the morning and every hour during the afternoon till seven o'clock. A maximum of 36 was observed at 11 A.M. The numbers then fell

[1] In Manchester, during the fine weather in the last fortnight of September, the numbers went up to 250.

irregularly till four o'clock, when the record was only 14. After that a rise took place (31 at 5 P.M. and 29 at 6 P.M.). At 7 P.M. no sensible force could be measured at all. The wind, which had been blowing up the valley all day, changed in direction between six and seven o'clock, and was blowing down the valley when the observations had to be discontinued, owing to want of light.

The author does not draw any conclusions from these observations, but does not believe that a mere difference in the configuration of the ground is sufficient to account for the great differences in the electric force observed.

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6. *On Indian Thunderstorms.* *By* C. MICHIE SMITH.

Observation shows that the ordinary hot-weather displays of sheet lightning take place in the region between the sea and land breezes where there are well-marked ascending currents, as shown by the great masses of pillared cumulus cloud. These clouds are usually in pairs, and much of the sheet lightning consists of discharges taking place between the two clouds forming such a pair. The land and sea breezes differ from each other in dryness and in dustiness, and many observations seem to show that thunderstorms are originated only where dry, dusty, and moist, and comparatively dustless air-currents meet. This explains why electrical phenomena are observed only in that part of a cyclone in which the air from the sea meets the air from the land, and why 'nor'-westers' are accompanied by such brilliant electrical displays. Dry, dusty air is usually negatively electrified relatively to the earth, while the sea breeze is usually positively electrified. The electrical displays take place in clouds that are rapidly sinking, and such clouds are often surrounded by an iridescent fringe (the colours of which are due probably to dust and moisture, as explained by Aitken, composed of the smaller particles left behind by the sinking cloud).

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7. *On the Zodiacal Light considered as an Atmospheric Phenomenon.* *By* W. H. WOOD.

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8. *On the Local Origin of the Aurora Borealis.* *By* W. H. WOOD.

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9. *Report on the Application of Photography to Meteorology.*

See Reports, p. 80.

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10. *Report on the Meteorological Observations on Ben Nevis.*

See Reports, p. 186.

MONDAY, SEPTEMBER 16.

1. A discussion 'on the Objective Character of Combination Tones' was introduced by the following Paper:—

Notes on the Objective Existence of Combination Tones.[1] *By* A. W. RÜCKER, *M.A.*, *F.R.S.*

It might at first sight appear that the question of the objective existence of combination tones would depend upon two others—viz. Are such notes heard? Do they exist as pulses in the air?

[1] In the following notes the references to statements of Von Helmholtz are for convenience made to the second English edition of the *Sensations of Tone*, translated by Ellis. The references to König's views are to *Quelques Expériences d'Acoustique.* Paris, 1882.

The matter, however, is not so simple. All agree that notes corresponding to the difference tone are heard under some circumstances, but many deny that they are produced as Von Helmholtz supposed, and would therefore deny that they are combination tones. Again, Von Helmholtz, who was the most prominent supporter of the objective reality of these notes, was also the author of the theory which explains their production within the ear itself.

It is therefore better to begin with the second question. Do notes corresponding in frequency with the combination tones accompany the two fundamental notes as air-waves under any circumstances?

The physical evidence for and against an affirmative answer is as following:—

Von Helmholtz stated that he had set membranes in motion by combination tones produced by the siren, and air resonators in motion by combination tones produced by the harmonium (Ellis, p. 157). I am not aware that the experiment with membranes has been repeated in the same form, but O. Lummer ('Verh. Phys. Gesell.,' Berlin, 1886, No. 9, p. 66) claimed to have detected the tones by means of the microphone. On the other hand, König (p. 130) denies that combination tones are reinforced by resonators; and Bosanquet satisfied himself that the ordinary first difference tone is incapable of exciting a resonator.

More recently, the writer and Mr. Edser, using as a resonator a tuning-fork of frequency 64, the motions of which were detected by attaching to one of the prongs a mirror which formed one of a system by which Michelson's interference bands were produced, have obtained evidence of the objective character of the summation and difference tones produced by a siren. They have confirmed these results in the case of the summation tone by a Rayleigh vane-resonator as modified by Boys ('Phil. Mag.,' April 1895, p. 341).

The only objection which, as far as the writer knows, has been brought against these experiments is that the tones detected must be of very small intensity; and Mr. Bosanquet has stated (in a letter) that he does not wish to be understood as denying the existence of very feeble combination tones.

It is unnecessary to quote experiments made by various observers with tuning-forks, as the use of these instruments is in general opposed to the directions and theories of Helmholtz. (Ellis, pp. 157, 158.)

On the whole, then, the evidence appears to be in favour of the view that objective notes of the same frequency as the combination tones do exist, at all events in special cases. Their relative intensity to the fundamental notes has not been determined, and is probably small.

Turning next to questions of theory, three explanations have been given of objective combination tones—viz., that they are due (1) to beats, (2) to finite displacements of the vibrating particles, and (3) to intermittence.

Among other objections to the first theory, Helmholtz pointed out that it would not explain the summation tone. (Ellis, p. 156).

Hence König suggested that the summation tone might be due to the beats of partials (König, p. 126). This explanation requires that, if p and q are the frequencies of the fundamentals, $p+q=n(p-q)$ where n is an integer. The writer and Mr. Edser have, however, obtained evidence of the objective existence of the summation tone when $p/q=16/9$, so that $n=25/7$ (*loc. cit.* p. 352). (See Ellis, p. 530.) Appunn and Preyer have suggested that the summation tone is the beat tone between the first partial of the higher note and the difference tone, for $2p-(p-q)=p+q$. König (p. 127) strongly opposes the adequacy of this explanation, which is contrary to his own observations on beats, and which fails to explain why the difference tone should not produce equally permanent effects by beating with the first partial of the lower note, thus giving $2q\sim(p-q)=3q-p$ or $p-3q$.

The theory of finite displacements is due to Helmholtz, who has shown (Ellis, p. 412) that if the elastic forces are not symmetrical about the position of equilibrium, the fundamental tones will be accompanied by the second partials and the difference and summation tones.

He has, however, also proved (Ellis, p. 420) that if in an instrument such as the siren the opening of one hole affects the pressure under which the air is simultaneously escaping out of the other, the quantity of air escaping may be represented in the simplest case by such a formula as

$$Q = C(1 - \sin 2\pi mt)(1 - \sin 2\pi nt)$$
$$= C[1 - \sin 2\pi mt - \sin 2\pi nt + \tfrac{1}{2}\{\cos 2\pi (m-n)t - \cos 2\pi (m+n)t\}],$$

thus giving rise to the first difference and summation tones.

A somewhat similar theory has since been elaborated by Terquem. ('Annales d'Ecole Normale,' 1870, p. 356).

At present it must be considered to be open to question whether the objective combination tones given by the siren are due to finite displacement or to intermittence, or to both causes combined.

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2. A Discussion 'on a New Practical Heat Standard.' Introduced by a Paper by E. H. Griffiths, F.R.S.

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3. *On the Thermal Conductivities of Mixtures of Liquids.* *By* Charles H. Lees, *D.Sc.*

The author has carried out a number of determinations of the thermal conductivities of mixtures of liquids by a method analogous to that of Christiansen, but with the heat supplied electrically and the temperature measured by means of thermo-junctions. For the mixtures of water, glycerine and alcohols experimented on, the conductivities are found to be less than the values calculated from the amounts and thermal conductivities of the constituents, and the author believes that this will be found to be a general law. A possible explanation may be found in the inability of one of the molecules of a mixture to take up and transmit the particular kind of vibration executed by the other.

For solutions of salts and gases in water the author finds conductivities less than that of water, in agreement with the results obtained by Jäger.

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4. *A Method of Comparing the Heats of Evaporation of Different Liquids at their Boiling Points. By* Professor W. Ramsay, *Ph.D., F.R.S., University College, London, and* Miss Dorothy Marshall, *B.Sc., University College, London.*

This method consists in making the liquid boil by passing an electric current through a wire immersed in it.

The liquid is put into a glass bulb enclosed in an outer jacket filled with vapour of the same liquid. An open tube is attached to the top of the bulb, so that there is free communication between the interior and the vapour jacket, and no loss of material. Inside the bulb is a spiral of fine platinum wire, attached to stout platinum terminals which are sealed into the glass. These terminals rest in mercury cups, by means of which connection is made. The temperature of the liquid in the bulb is raised to the boiling-point by the vapour jacket; thus when a current is sent through the wire the whole of the heat developed is spent in converting a portion of the liquid into vapour.

If two such bulbs containing different liquids are connected in series, the ratio of their losses of weight is the inverse ratio of the heats of evaporation of the liquids.

A correction must be made for the inequality in resistance of the spirals. The ratio of the differences of potential between the ends of each spiral while the current is passing is determined in each experiment by Poggendorff's method.

TABLE I.

—	Ratio to Benzene	L found	L calculated	Other Observers
Toluene	0·920	86·8	—	83·6 Schiff.
Metaxylene	0·877	82·8	—	78·3 Schiff.
Alcohol	2·293	216·5	—	202·4 Andrews.
				227·0 Brix.
				208·0 Despretz.
				208·9 Favre and Silbermann.
				206·4 Schall.
				205·0 Wirtz.
				201·4 Longuinine.
Acetic Acid	1·028	97·0	92·7	120·8 Berthelot.
				84·9 Berthelot and Ogier.
				101·9 Favre and Silbermann.
Methyl Formate	1·167	110·1	119·1	117·1 Andrews.
				115·2 Berthelot.
Ethyl Formate	1·000	94·4	93·4	105·3 Andrews.
				100·4 Berthelot.
				92·2 Schiff.
				113·25 Jahn.
Methyl Acetate	1·028	97·0	96·8	110·2 Andrews.
				94·0 Schiff.
				113·86 Jahn.
Propyl Formate	0·956	90·2	87·3	85·3 Schiff.
Ethyl Acetate	0·899	84·9	84·3	92·7 Andrews.
				83·1 Schiff.
				84·3 Wirtz.
				102·14 Jahn.
Methyl Propionate	0·942	89·0	87·7	84·2 Schiff.
Propyl Acetate	0·881	83·2	—	77·3 ,,
Ethyl Propionate	0·867	81·8	—	77·1 ,,
Methyl Butyrate	0·844	79·7	—	77·3 ,,
Methyl Isobutyrate	0·794	75·0	—	75·5 ,,

TABLE II.

—	Ratio to Benzene	L	t	M	$\frac{ML}{T}$
Benzene	1·000	94·4	80°·2	77·40	20·65
Toluene	0·920	86·8	110·8	91·30	20·61
Metaxylene	0·877	82·8	138·5	105·20	21·03
Alcohol	2·293	216·5	78·2	45·66	28·09
Acetic Acid	1·028	97·0	118·5	59·52	14·72
Water	0·176	537·0	100·0	17·86	25·64
Methyl Formate	1·167	110·1	31·8	59·52	21·45
Ethyl Formate	1·000	94·4	54·3	73·42	21·13
Methyl Acetate	1·028	97·0	57·1	73·42	21·53
Propyl Formate	0·956	90·2	80·9	87·32	22·38
Ethyl Acetate	0·899	84·9	77·15	87·32	22·13
Methyl Propionate	0·943	89·0	79·7	87·32	21·99
Propyl Acetate	0·881	83·2	101·25	101·22	22·45
Ethyl Propionate	0·867	81·8	99·0	101·22	22·22
Methyl Butyrate	0·844	79·7	102·7	101·22	21·43
Methyl Isobutyrate	0·794	75·0	92·3	101·22	20·74

In Table II.—

L is the heat of evaporation;

t the temperature of the boiling-point;

M the molecular weight;

$\frac{ML}{T}$ the quotient of the molecular heat of evaporation by the absolute temperature: according to Tronton's Law this should be constant.

If the heat of vaporisation of any one liquid be known, the absolute value of the heat of vaporisation for any other liquid can be calculated from the ratio. Water was originally selected as the standard liquid, but it proved to be quite unsuitable: experiments in which one of the liquids was water never gave concordant results. It appears impossible by any ordinary means to get water so pure that conduction across it and the consequent polarisation may be disregarded. The liquid finally adopted as the standard is *benzene*, for which $L = 94{\cdot}4$ at $80^\circ{\cdot}2$.[1]

The heat of evaporation may also be calculated from the thermodynamic equation, $L = (s' - s)\frac{dp}{dt} \cdot \frac{T}{J}$, when the necessary data can be found.

The value of J adopted in these calculations is that given by Griffiths[2] and used in working out the experiments on benzene. Even if not correct, it is still the right value to use here, because it was determined by means of the same standards as those by which the quantity of heat developed in the benzene experiments was determined, so that any errors would eliminate.

The other data were experimental.

The agreement between the found and calculated values of L is fairly close in most of the cases examined. The work is still in progress.

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5. *On a Harmonic Analyser.* *By* G. U. Yule.

The author exhibited the instrument, which is fully described in the 'Philosophical Magazine' for April 1895.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *On the Electrification and Diselectrification of Air and other Gases.* *By* Lord Kelvin, Magnus Maclean, *and* Alexander Galt.

§ 1. Experiments were made for the purpose of finding an approximation to the amount of electrification communicated to air by one or more electrified needle points. The apparatus consisted of a metallic can 48 cm. high and 21 cm. in diameter, supported by paraffine blocks, and connected to one pair of quadrants of a quadrant electrometer. It had a hole at the top to admit the electrifying wire, which was 5·31 metres long, hanging vertically within a metallic guard tube. This guard tube was always metallically connected to the other pair of quadrants of the electrometer and to its case, and to a metallic screen surrounding it. This prevented any external influences from sensibly affecting the electrometer, such as the working of the electric machine which stood on a shelf 5 metres above it.

§ 2. The experiment is conducted as follows:—One terminal of an electric machine is connected with the guard tube and the other with the electrifying wire which is let down so that the needle is in the centre of the can. The can is temporarily connected to the case of the electrometer. The electric machine is

[1] Griffiths and Marshall. [2] *Phil. Trans.*, 184 A (1893).

then worked for some minutes, so as to electrify the air in the can. As soon as the machine is stopped the electrifying wire is lifted clear out of the can. The can and the quadrants in metallic connection with it are disconnected from the case of the electrometer, and the electrified air is very rapidly drawn away from the can by a blowpipe bellows arranged to exhaust. This releases the opposite kind of electricity from the inside of the can, and allows it to place itself in equilibrium on the outside of the can and on the insulated quadrants of the electrometer in metallic connection with it.

§ 3. We tried different lengths of time of electrification, and different numbers of needles and tinsel, but we found that one needle and four minutes of electrification gave nearly maximum effect. The greatest deflection observed was 936 scale divisions. To find, from this reading, the electric density of the air in the can, we took a metallic disc, of 2 cm. radius, attached to a long varnished glass rod, and placed it at a distance of 1·45 cm. from another and larger metallic disc. This small air condenser was charged from the electric light conductors in the laboratory to a difference of potential amounting to 100 volts. The insulated disc thus charged was removed and laid upon the roof of the large insulated can. This addition to the metal in connection with it does not sensibly influence its electrostatic capacity. The deflection observed was 122 scale divisions. The capacity of the condenser is approximately $\frac{\pi \times 2^2}{4\pi \times 1{\cdot}45} = \frac{1}{1{\cdot}45}$. The quantity of electricity with which it was charged was $\frac{1}{1{\cdot}45} \times \frac{100}{300} = \frac{1}{4{\cdot}35}$ electrostatic unit. Hence the quantity to give 936 scale divisions was $\frac{1}{4{\cdot}35} \times \frac{936}{122} = 1{\cdot}7637$.

The bellows was worked vigorously for two and a half minutes, and in that time all the electrified air would be exhausted. The capacity of the can was 16,632 cubic centimetres, which gives, for the quantity of electricity per cubic centimetre, $\frac{1{\cdot}7637}{16632} = 1{\cdot}06 \times 10^{-4}$. The electrification of the air in this case was positive: it was about as great as the greatest we got, whether positive or negative, in common air when we electrified it by discharge from needle points. This is about four times the electric density which we roughly estimated as about the greatest given to the air in the inside of a large metal vat, electrified by a needle point and then left to itself, and tested by the potential of a water-dropper with its nozzle in the centre of the vat, in experiments made two years ago, and described in a communication to the Royal Society of date May 1894.[1]

§ 4. In subsequent experiments electrifying common air in a large gas-holder over water by an insulated gas flame burning within it with a wire in the interior of the flame kept electrified by an electric machine to about 6,000 volts, whether positively or negatively, we found as much as $1{\cdot}5 \times 10^{-4}$ for the electric density of the air. Electrifying carbonic acid in the same gas-holder, *whether positively or negatively*, by needle points, we obtained an electric density of $2{\cdot}2 \times 10^{-4}$.

§ 5. We found about the same electric density ($2{\cdot}2 \times 10^{-4}$) of *negative* electricity in carbonic acid gas drawn from an iron cylinder lying horizontally, and allowed to pass by a U-tube into the gas-holder without bubbling through the water. This electrification was due probably not to carbonic acid gas rushing through the stopcock of the cylinder, but to bubbling from the liquid carbonic acid in its interior, or to the formation of carbonic acid snow in the passages and its subsequent evaporation. When carbonic acid gas was drawn slowly from the liquid carbonic acid in the iron cylinder placed upright, and allowed to pass, without bubbling, through the U-tube into the gas-holder over water, no electrification was found in the gas unless electricity was communicated to it from needle points.

§ 6. The electrifications of air and carbonic acid described in Sections 4 and 5 were tested, and their electric densities measured, by drawing by an air pump

[1] *On the Electrification of Air.* By Lord Kelvin and Magnus Maclean.

a measured quantity of the gas[1] from the gas-holder through an indiarubber tube to a receiver of known efficiency and of known capacity in connection with the electrometer. We have not yet measured how much electricity was lost in the passage through the indiarubber tube. It was not probably nothing; and the electric density of the gas before leaving the gas-holder was no doubt greater, though perhaps not much greater, than what it had when it reached the electric receiver.

§ 7. The efficiency of the electric receivers used was approximately determined by putting two of them in series, with a paraffine tunnel between them, and measuring by means of two quadrant electrometers the quantity of electricity which each took from a measured quantity of air drawn through them. By performing this experiment several times, with the order of the two receivers alternately reversed, we had data for calculating the proportion of the electricity taken by each receiver from the air entering it, on the assumption that the proportion taken by each receiver was the same in each case. This assumption was approximately justified by the results.

§ 8. Thus we found for the efficiencies of two different receivers respectively 0·77 and 0·31 with air electrified positively or negatively by needle points; and 0·82 and 0·42 with carbonic acid gas electrified negatively by being drawn from an iron cylinder placed on its side. Each of these receivers consisted of block tin pipe 4 cm. long and 1 cm. diameter, with five plugs of cotton wool kept in position by six discs of fine wire gauze. The great difference in their efficiency was, no doubt, due to the quantities of cotton wool being different, or differently compressed in the two.

§ 9. We have commenced, and we hope to continue, an investigation of the efficiency of electric receivers of various kinds, such as block tin, brass, and platinum tubes from 2 to 4 cm. long and from 1 mm. to 1 cm. internal diameter, all of smooth bore and without any cotton wool or wire gauze filters in them; also a polished metal solid insulated within a paraffine tunnel. This investigation, made with various quantities of air drawn through per second have already given us some interesting and surprising results, which we hope to describe after we have learned more by further experimenting.

§ 10. In addition to our experiments on electric filters we have made many other experiments to find other means for the diselectrification of air. It might be supposed that drawing air in bubbles through water should be very effective for this purpose, but we find that this is far from being the case. We had previously found that non-electrified air drawn in bubbles through pure water becomes negatively electrified, and through salt water positively. We now find that positively electrified air drawn through pure water, and negatively electrified air through salt water, has its electrification diminished but not annulled if the primitive electrification is sufficiently strong. Negatively electrified air drawn in bubbles through pure water, and positively electrified air drawn through salt water, has its electrification augmented.

§ 11. To test the effects of heat we drew air through combustion tubes of German glass about 180 cm. long and $2\frac{1}{2}$ or $1\frac{1}{2}$ cm. bore, the heat being applied externally to about 120 cm. of the length. We found that when the temperature was raised to nearly a dull red heat, air, whether positively or negatively electrified, lost little or nothing of its electrification by being drawn through the tube. When the temperature was raised to a dull red heat, and to a bright red, high enough to soften the glass, losses up to as much as four-fifths of the whole electrification were sometimes observed, but never complete diselectrification. The results, however, were very irregular. Non-electrified air never became sensibly electrified by being drawn through the hot glass tubes in our experiments; but it gained strong posi-

[1] The gas-holder was 38 cm. high and 81 cm. in circumference. Ten strokes of the pump raised the water inside to a height of 8·1 cm., so that the volume of air drawn through the receivers in the experiments was 428 cubic cm. per stroke of the pump. This agrees with the measured effective volume of the two cylinders of the pump.

tive electrification when pieces of copper foil, and negative electrification when pieces of carbon, were placed in the tube, and when the temperature was sufficient to powerfully oxidise the copper or to burn away the charcoal.

§ 12. Through the kindness of Mr. E. Matthey, we have been able to experiment with a platinum tube 1 metre long and 1 mm. bore. It was heated either by a gas flame or an electric current. When the tube was cold, and non-electrified air drawn through it, we found no signs of electrification by our receiver and electrometer. But when the tube was made red or white hot, either by gas burners applied externally or by an electric current through the metal of the tube, the previously non-electrified air drawn through it was found to be electrified strongly positive. To get complete command of the temperature we passed a measured electric current through 20 cm. of the platinum tube. On increasing the current till the tube began to be at a scarcely visible dull red heat we found but little electrification of the air. When the tube was a little warmer, so as to be quite visibly red hot, large electrification became manifest. Thus 60 strokes of the air-pump gave 45 scale divisions on the electrometer when the tube was dull red, and 395 scale divisions (7 volts) when it was a bright red (produced by a current of 36 ampères). With stronger currents, raising the tube to white-hot temperature, the electrification seemed to be considerably less.

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2. *Do Vertical (Earth-Air) Electric Currents Exist in the United Kingdom?* By A. W. Rücker, *F.R.S.*

In a paper by Dr. Adolph Schmidt read before Section A of the British Association at Oxford,[1] the author stated that he had expanded the components of the earth's magnetic force in series, and had deduced expressions, two of which give the magnetic potential on the surface of the earth in so far as it depends on (1) internal and (2) external forces. 'The third series represents that part of the magnetic forces which cannot be expressed in terms of a potential, but must be due to electric currents traversing the earth's surface.' The author concludes that such currents amount 'on the average to about 0·1 ampere per square kilometre.'

It appeared, therefore, desirable that this conclusion, drawn from the magnetic state of the earth as a whole, should be tested by means of those portions which have been most fully studied.

The test to be applied is whether the line integral of the magnetic force taken round a re-entrant circuit is or is not a vanishing quantity.

The irregular form of the United Kingdom makes the application of this test more difficult than it would otherwise be, but as two detailed surveys of Great Britain and Ireland have been carried out by Dr. Thorpe and myself for the epochs 1886 and 1891 respectively, the data at our disposal are so numerous that I thought it worth while to undertake the inquiry. The actual work of calculation has been carried out almost entirely by two of my students, Messrs. Kay and Whalley. My best thanks are due to them for the care and skill they have displayed.

Two circuits called the α and β circuits respectively were selected, bounded by the following lines:—

(α) Long. 2° W., Lat. 58° N.; Long. 7° W., Lat. 52° N.
(β) Long. 1° W., Lat. 55° N.; Long. 9° W., Lat. 52° N.

The work done by a unit magnetic pole on traversing these circuits was calculated for the epoch 1886·0 by means of the terrestrial lines found for that date, and also for the epoch 1891·0 by means (1) of the same lines when due allowance was made for the secular change, and (2) of the independent set of lines found by aid of the later survey.

The magnitudes of the hypothetical currents deduced from these calculations

[1] *Rep. Brit. Assoc.*, 1894, p. 570.

were very small, and those for the later epoch were of opposite signs, according as they were calculated from the earlier or the later survey.

The same calculation was made for two other circuits, one (γ) in Great Britain and one (δ) in Ireland; but instead of using the calculated terrestrial lines, the true values of the forces and declinations were employed, as deduced from the nearest stations. The great local disturbances in Antrim interfered with the value of the Irish circuit. The following table gives the results in amperes per square kilometre obtained from circuits a and β by the terrestrial lines for 1886·0, and also by the mean terrestrial lines for 1891·0, which occupy the mean position between those given by the two independent surveys, and lastly the results for circuit (γ).

Circuit.

	a	β	γ
1886·0	−0·026	−0·004	—
1891·0	+0·001	−0·005	—
1891·0	—	—	−0·008

From these we may conclude that there is not in the United Kingdom a vertical current amounting on the average to 0·1 ampere per square kilometre. There may possibly be a current of about a tenth or a twentieth of that amount, and if so the signs show that it probably flows from air to earth, but on account both of the smallness of the results and of the discrepancy between the values obtained for 1891 by two independent calculations, we cannot assert that such a current actually exists.

The calculations do not disprove Dr. Schmidt's hypothesis, as we cannot argue from the condition of a small portion of the earth's surface to that of the whole. The most that can be said is that no evidence in favour of the existence of vertical currents can be drawn from one district which has been very minutely surveyed.

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3. *On the Equation Connecting the Potential Difference, Current, and Length of the Electric Arc.* *By* Mrs. Ayrton.

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4. *On the back E.M.F. and True Resistance of the Electric Arc.* *By* Professor W. E. Ayrton, *F.R.S.*, and T. Mather.

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5. *Note on the Electrolysis of Iron Salts.* *By* W. M. Hicks, *F.R.S.*, *and* L. T. O'Shea.

To prepare iron free from sulphur and carbon by electrolysis we used a solution of the double ferrous ammonium chloride. Large masses of metal can only be obtained by paying particular attention to the following points.

1. The strict neutrality of the solution: its strength must be regulated so as to offer suitable resistance for the regulation of the potential difference between the terminals and of the current density. We used a five per cent. solution of ferrous chloride to which sufficient ammonium chloride was added to form the double salt. This strength must be maintained, for if the amount of iron salt falls too low the ammonium chloride is decomposed and ferrous hydroxide is precipitated.

The solution should be free from ferric salt, as this causes the formation of ferric hydroxide, which settles on the cathode plate. The solution can be freed from ferric salts by shaking with reduced iron and filtering just before being used.

2. The current density. For electrolytic analysis Classen gives a current density of 0·05 to 1·0 ampère per 100 sq. cm., and S. P. Thompson 0·08 to 0·25 ampère per 100 sq. cm. for steel facing. We find that it is advisable to strike the deposit with a density of 0·2 ampère per 100 sq. cm., then reduce to 0·15 to 0·18 ampère per 100 sq. cm., and that this should not be exceeded, though densities as low as 0·08 can be used.

The potential difference between the terminals we used was 0·7 volt, and this was obtained by placing a single storage cell, voltage 2, in series with a dilute sulphuric acid cell with lead electrodes and a small external resistance.

3. The electrodes. The cathode must present a perfectly clean surface. We used thin copper sheet and found the best method of cleaning was to flush it with nitric acid and then scrub it with excess of a strong solution of potassium cyanide.

All parts of the cathode except that on which the deposit is to form must be insulated from the solution. This may be done by coating the necessary parts with Brunswick black, on which, if perfectly dry, the solution has no action.

The anode was a sheet of rolled Swedish iron, and to prevent the impurities it contained from mixing with the electrolyte it was enclosed in a porous cell. The accumulation of sulphuric acid in the electrolyte was prevented as much as possible by changing the solution in this cell twice daily. The solution used contained one per cent. ferrous chloride. The surface of the cathode is covered with small conical cavities, due to the formation of microscopic gas bubbles; in the early stages of the deposition great care must be taken to remove these by periodically exposing the surface to the air and in addition rubbing the surface. By taking these precautions the process can be carried on without interruption, and a firm, coherent deposit obtained of great purity.

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6. *On a Magnetic Field Tester.* *By* Professor W. E. Ayrton, *F.R.S., and* T. Mather.

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7. *On the Velocity of Light in Rarefied Gases through which an Electrical Discharge is passing.* *By* Edwin Edser, *A.R.C.S., and* Sydney G. Starling, *A.R.C.S.*

Lord Rayleigh has published the result of a research relative to the velocity of light in an electrolyte through which an electric current is passing. Dilute sulphuric acid was used, and the conclusion reached was that the velocity was unaffected by the passage of the current.

It seemed to us worth while to perform a similar experiment to the above, substituting a rarefied gas for the electrolyte. The conditions are somewhat different, for though it has been shown by Professor J. J. Thomson that the ordinary stratified discharge can be assimilated to a current passing through an electrolyte by considering each stratification to correspond to a Grotthus chain, yet there is left still outstanding the phenomenon known as the kathode rays. Professor J. J. Thomson considers these rays to consist of a number of atoms, each carrying its tubes of force, and moving with a velocity comparable with 2×10^5 cm. per second. If these tubes of force consist of or comprise a number of vortex filaments of the ether, we might reasonably hope to detect some difference in the velocity of the light, according as it moves with or against this ether current.

The method used by us is essentially that employed by Professor Michelson in re-performing Fizeau's experiment, two vacuum tubes with plane glass ends being substituted for the tubes through which in his experiment water was caused to flow. A discharge was produced in these tubes by a Ruhmkorff coil, and the interference bands were carefully observed. No alteration could be detected on the discharge being reversed. The experiment was repeated at various pressures (determined by the McLeod gauge) with the same result.

A valid objection which might be raised to the above experiments is, that on account of the extremely short duration of these discharges, which succeeded each other only a few times a second, any shift of the bands would not be capable of detection by the observer. The most satisfactory results could be obtained by using a constant current from a battery of a large number of cells; but as these were not at our command, we attempted to obtain a prolonged discharge from a battery of ten one gallon Leyden jars, a piece of wet string being included in the circuit. The jars were charged by means of the above-mentioned Ruhmkorff coil, suitable arrangements being made for the purpose; and the discharges occasionally succeeded each other so quickly that for some seconds the phenomena were apparently continuous. The duration of each discharge was determined by means of Mr. Boys's wheel of lenses, and was found to exceed $\frac{1}{30}$ second. Not the slightest flicker of the bands could, however, be detected.

A check experiment was then performed by dropping a piece of plate glass, which would produce a shift of the bands when placed in the path of the light, from such a height that its effect would last $\frac{1}{25}$ second and $\frac{1}{100}$ second respectively. In each of these cases a flicker was observed.

From this we conclude that the kathode rays and the positive column, either alone or conjointly, do not affect the velocity of light passing along their path.

8. *On the Hysteresis of Iron in an Alternating Magnetic Field.* *By* Francis G. Baily, *M.A.*

The law connecting hysteresis and induction when the latter reaches a high value has not until now been ascertained. It has hitherto been assumed that the hysteresis would increase continuously with the induction without limit. It is, however, probable that in a slowly performed cycle of change of magnetisation a maximum value of the hysteresis will be reached when the iron is saturated, and that further increase of the number of lines of force induced will produce no further increase in the hysteresis. When a rapidly alternating field is considered the conditions are somewhat different. As the magnetising current is increased the iron reaches its saturation value at an earlier point in each period, thus increasing the rate of change of magnetisation. But it has been shown by different experimenters that the value of the hysteresis per cycle is practically unchanged through wide variations in speed, and hence it may be expected that the hysteresis of iron under all conditions will arrive at a definite maximum.

To verify this experimentally, the hysteresis in a small sample of iron was measured, when it was placed between the poles of a powerful electromagnet excited by an alternating current. Both magnet and sample were laminated, the subdivision of the latter being especially fine, in order to eliminate as far as possible errors due to eddy currents. The sheets consisted of soft charcoal-iron of thickness ·0085 cm., and between each was a layer of tissue paper. The maximum value of the eddy currents was less than 2 per cent. of the hysteresis. The hysteresis was measured by the rise in temperature of the iron after 90 seconds, the speed of alternation being constant at 103 cycles per second. The sides of the sample were coated with layers of sheet cork, the radiation being very small. At the end sufficient protection could not be allowed owing to the small size of the air-gap, and hence transference of heat was prevented by maintaining equality of temperature between the pole pieces and the sample by means of streams of hot or cold paraffin oil over the pole pieces. All temperatures were measured by thermoelectric couples of german silver and copper.

The experiments show that the curve when plotted with the induction as abscissa, and the hysteresis as ordinate, exhibits a flexure at an induction of about 16,000, and becomes practically horizontal at 23,000. This corresponds to a value of intensity of magnetisation of 1,640, which is just the saturation value.

The same characteristics are observed when the intensity of magnetisation is taken as the abscissa, the curve bending over until it is almost horizontal at the point of saturation.

The experiments prove that the hysteresis of iron is a function, not of induction, but of intensity of magnetisation, since both values become constant together, and that the relation between them is not a logarithmic curve, but is a curve showing one flexure, and clearly indicating in its upper portion the condition of the iron represented by Professor Ewing's third stage of magnetisation.

WEDNESDAY, SEPTEMBER 18.

The following Papers and Report were read:—

1. *On the Change of Molecular Refraction in Salts or Acids dissolved in Water. By* Dr. J. H. GLADSTONE, *F.R.S., and* WALTER HIBBERT, *F.I.C.*

The authors had recently undertaken a research on the questions—Does the specific refractive energy of a salt or acid when deduced from its solution in water differ from that of the solid compound? and Does the specific refractive energy vary according to the amount of water? The outcome of the experiments of the authors and others is that the water does bring about in many cases a small alteration, especially in passing from the solid or liquid to the dissolved condition; that this alteration is sometimes an increase, at other times a decrease; and that it depends upon the chemical nature of the compound. Some points of physical interest were, however, noted, and were being more fully examined. One of these is the analogy of this refraction change in several instances with the change in the power to rotate the plane of polarised light as determined by Dr. Perkin. As this small change of refraction evidently indicates some rearrangement of the constituents of the salt or acid in the water, it may throw light upon present theories of solution. The experiments, even those of Kohlrausch and Hallwachs on extremely dilute solutions, do not support the view that the binary compound when greatly diffused tends to exhibit the properties of a gas. There is an evident relation between this change of refraction and the electric conductivity of the solution. Thus, in the acids the order of the two phenomena is the same, the hydrochloric acid showing the greatest effect, rapidly followed by hydrobromic and hydriodic acids; then nitric acid, afterwards sulphuric acid; and at a great distance acetic and other organic acids. In the case of nitric and sulphuric acids the general form of the curves representing the change of electric conductivity and of refraction is similar; in the case of the latter there is a special depression during the rise of the conductivity curve which makes its appearance as a slackening of the rise in the curve representing change of refraction. This connection of the two phenomena is being further carefully examined at present.

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2. *Report on Electrical Standards.*—See Reports, p. 195.

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3. *On the Choice of Magnetic Units.*
By Professor SILVANUS P. THOMPSON, *F.R.S.*

Professor Silvanus Thompson pointed out that the giving of names was a detail, and that agreement was wanted upon the units themselves in which magnetic quantities were to be expressed. He agreed with the Standards Committee that the two most important units to be defined were those of magnetic flux and of magnetic potential, and urged that no other units should be defined until these had been tried. But he differed from the suggestion to take the *weber* as 10^8 C.G.S. *lines* as being a unit of too great an order of magnitude to suit practical needs. He preferred simply to take the *line*, with its natural multiples the *kiloline*, and the *megaline* as the unit of flux. If the name *weber* were given to the line itself the Committee's recommendation would then be identical, so far as this unit is concerned, with that of the American Institute of Electrical Engineers. He agreed with the propositions to adopt the name *gauss* for the C.G.S. unit of *magnetic* potential.

4. *On some New Methods and Apparatus for the Delineation of Alternate Current Wave Forms. By* J. M. BARR, W. B. BURNIE, *and* CHARLES RODGERS.

5. *On Alternating Wave Tracers.*
By Professor W. E. AYRTON, *F.R.S.*, *and* T. MATHER.

6. *On the Relation between Speed and Voltage in Electric Motors.*
By Professor W. E. AYRTON, *F.R.S.*, *and* T. MATHER.

7. *On some recent Improvements in Measurements of High Temperatures. Illustrated by Apparatus recently acquired by the Kew Observatory Committee. By* E. H. GRIFFITHS, *F.R.S.*

Section B.—CHEMISTRY.

President of the Section.—Professor R. Meldola, F.R.S., For.Sec.C.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

The State of Chemical Science in 1851.

In order to estimate the progress of chemical science since the year 1851, when the British Association last met in this town, it will be of interest for us to endeavour to place ourselves in the position of those who took part in the proceedings of Section B on that occasion. Perhaps the best way of performing this retrograde feat will be to confront the fundamental doctrines of modern chemistry with the state of chemical theory at that period, because at any point in the history of a science the theoretical conceptions in vogue—whether these conceptions have survived to the present time or not—may be taken as the abstract summation of the facts, *i.e.*, of the real and tangible knowledge existing at the period chosen as the standard of reference.

Without going too far back in time I may remind you that in 1811 the atomic theory of the chemists was grafted on to the kindred science of physics through the enunciation of the law associated with the name of Avogadro di Quaregna. The rationalising of this law had been accomplished in 1845, but the kinetic theory of gases, which had been foreshadowed by D. Bernoulli in 1738, and in later times by Herapath, Joule, and Krönig, lay buried in the archives of the Royal Society until recently unearthed by Lord Rayleigh and given to the world in 1892 under the authorship of Waterston, the legitimate discoverer. The later developments of this theory did not take place till after the last Ipswich meeting, viz., in 1857–1862, by Clausius, and by Clerk Maxwell in 1860–1867. Thus the kinetic theory of gases of the physicists had not in 1851 acquired the full significance for chemists which it now possesses: the hypothesis of Avogadro was available, analogous conceptions had been advanced by Davy in 1812, and by Ampère in 1814; but no substantial chemical reasons for its adoption were adduced until the year 1846, when Laurent published his work on the law of even numbers of atoms and the nature of the elements in the free state.[1]

The so-called 'New Chemistry' with which students of the present time are familiar was, in fact, being evolved about the period when the British Association last assembled at Ipswich; but it was not till some years later, and then chiefly through the writings of Laurent and Gerhardt, that the modern views became accepted. It is of interest to note in passing that the nomenclature of organic compounds formed the subject of a report by Dr. Daubeny at that meeting in which he says:—'It has struck me as a matter of surprise that none of the British treatises on Chemistry with which I am acquainted should contain any rules to guide us, either in affixing names to substances newly discovered or

[1] *Ann. Chim. Phys.* [3]. **18**, 266.

in divining the nature and relations of bodies from the appellations attached to them. Nor do I find this deficiency supplied in a manner which to me appears satisfactory when I turn to the writings of Continental chemists.' In a subsequent portion of the report Dr. Daubeny adds:—'No name ought, for the sake of convenience, to exceed in length six or seven syllables.' I am afraid the requirements of modern organic chemistry have not enabled us to comply with this condition.

Among other physical discoveries which have exerted an important influence on chemical theory the law of Dulong and Petit, indicating the relationship between specific heat and atomic weight, had been announced in 1819, had been subsequently extended to compounds by Neumann, and still later had been placed upon a sure basis by the classical researches of Regnault in 1839. But here, again, it was not till after 1851 that Cannizzaro (1858) gave this law the importance which it now possesses in connection with the determination of atomic weights. Thermo-chemistry as a distinct branch of our science may also be considered to have arisen since 1851, although the foundations were laid before this period by the work of Favre and Silbermann, Andrews, Graham, and especially Hess, whose important generalisation was announced in 1840, and whose claim to just recognition in the history of physical chemistry has been ably advocated in recent times by Ostwald. But the elaboration of thermochemical facts and views in the light of the dynamical theory of heat was first commenced in 1853 by Julius Thomsen, and has since been carried on concurrently with the work of Berthelot in the same field which the latter investigator entered in 1865. Electro-chemistry in 1851 was in an equally rudimentary condition. Davy had published his electro-chemical theory in 1807, and in 1812 Berzelius had put forward those views on electric affinity which became the basis of his dualistic system of formulation. In 1833 Faraday announced his famous law of electro-chemical equivalence, which gave a fatal blow to the conception of Berzelius, and which later (1839–1840) was made use of by Daniell in order to show the untenability of the dualistic system. By 1851 the views of Berzelius had been abandoned, and, so far as chemical theory is concerned, the whole subject may be considered to have been in abeyance at that time. It is of interest to note, however, that in that year Williamson advanced on quite distinct grounds his now well-known theory of atomic interchange between molecules, which theory in a more extended form was developed independently from the physical side and applied to electrolytes by Clausius in 1857. The modern theory of electrolysis associated with the names of Arrhenius, van 't Hoff, and Ostwald is of comparatively recent growth. It appears that Hittorf in 1878 was the first to point out the relationship between electrolytic conductivity and chemical activity, this same author as far back as 1856 having combated the prevailing view that the electric current during electrolysis does the work of overcoming the affinities of the ions. Arrhenius formulated his theory of electrolytic dissociation in 1887, Planck having almost simultaneously arrived at similar views on other grounds.

Closely connected with electrolysis is the question of the constitution of solutions, and here again a convergence of work from several distinct fields has led to the creation of a new branch of physical chemistry which may be considered a modern growth. The relationship between the strength of a solution and its freezing point had been discovered by Blagden towards the end of the last century, but in 1851 chemists had no notion that this observation would have any influence on the future development of their science. Another decade elapsed before the law was rediscovered by Rüdorff (1861(and ten years later was further elaborated by de Coppet. Raoult published his first work on the freezing point of solutions in 1882, and two years later the relationship between osmotic pressure and the lowering of freezing point was established by H. de Vries, who first approached the subject as a physiologist, through observations on the cell contents of living plants. As the work done in connection with osmotic pressure has had such an important influence on the 'dissociation' theory of solutions, it will be of interest to note that at the last Ipswich meeting Thomas Graham made a communication on liquid diffusion, in which he 'gave a view of some of the unpublished results, to ascertain whether solutions of saline bodies had a power of diffusion among liquids, especially water.' In 1877 Pfeffer, who, like de Vries, entered the field from the botanical physiological side, succeeded in effecting the measurement of osmotic pressure. Ten years later van 't Hoff formulated the modern dissociation theory of solution by applying to dissolved substances the laws of Boyle, Gay-Lussac, and Avogadro, the law of osmotic pressure, and Raoult's law connecting the depression of freezing point with molecular weight, thus laying the foundation of a doctrine which, whether destined to survive in its present form or not, has certainly exerted a great influence on contemporary chemical thought.

Consider, further, the state of knowledge in 1851 concerning such leading principles as dissociation or thermolysis, mass action, and chemical equilibrium. Abnormal vapour densities had been observed by Avogadro in 1811, and by Ampère in 1814. Grove had dissociated water vapour by heat in 1847, but the first great advance was made ten years later by Sainte-Claire Deville, from whose work has emanated our existing knowledge of this subject. I may add that the application of this principle to explain the cases of abnormal vapour density was made in 1858 by Kopp, Kekulé, and Cannizzaro almost simultaneously; but, strangely enough, this explanation was not accepted by Deville himself. The subsequent stages are subjects of modern history. The current views on mass action were foreshadowed, as is well known, by Berthollet in his 'Statique Chimique,' published in 1803, but no great advance had been made when the British Association last met here. The subject first began to assume a quantitative aspect through the researches of Bunsen and Debus in 1853, and was much advanced by Gladstone in 1865, and by Harcourt and Esson a year later. Guldberg and Waage published their classical work on this subject in 1867.

Equally striking will appear the advances made since 1851 if we consider that the whole subject of spectrum analysis, which brings our science into relationship with astronomy, has been called into existence since that date. The celebrated work of Bunsen and Kirchhoff was not published till 1859. Neither can I refrain from reminding you that the coal-tar colour industry, with which I have been to a small extent connected, was started into activity by Perkin's discovery of mauve in 1856; the reaction of this industry on the development of organic chemistry is now too well known to require further mention. In that direction also which brings chemistry into relationship with biology the progress has been so great that it is not going beyond the fact to state that a new science has been created. Pasteur began his studies on fermentation in 1857, and out of that work has arisen the science of bacteriology, with its multifarious and far-reaching consequences. As this chapter of chemical history forms the subject of one of the evening discourses at the present meeting, it is unnecessary to dwell further upon it now. One other generalisation may be chronicled among the great developments achieved since 1851. I refer to the periodic law connecting the atomic weights of the chemical elements with their physical and chemical properties. Attempts to establish numerical relationships in the case of isolated groups of elements had been made by Döbereiner in 1817, by Gmelin in 1826, and again by Döbereiner in 1829. The triad system of grouping was further developed by Dumas in 1851. I am informed by Dr. Gladstone that at the last Ipswich meeting Dumas' speculations in this direction excited much interest. All the later steps of importance have, however, been made since that time, viz., by de Chancourtois in 1862, the 'law of octaves' by Newlands in 1864, the periodic law by Mendeléeff, and almost contemporaneously by Lothar Meyer in 1869.

I have been tempted into giving this necessarily fragmentary and possibly tedious historical sketch because it is approaching half a century since the British Association visited this town, and the opportunity seemed favourable for going through that process which in commercial affairs is called 'taking stock.' The result speaks for itself. Our students of the present time who are nourished intellectually by these doctrines should be made to realise how rapid has been their development. The pioneers of our science on whose shoulders we stand—and many of whom are happily still among us—will derive satisfaction from the retrospect, and will admit that their labours have borne goodly fruit. It is not, however, simply for the purpose of recording this enormous progress that I have ventured to assume the office of stock-taker. The year 1851 may be regarded as occurring towards the close of one epoch and the dawn of a new era in chemical history. Consider broadly the state of organic chemistry at that time. There is no occasion for going into detail, even if time admitted, because our literature has recently been enriched by the concise and excellent historical works of Schorlemmer and of Ernst von Meyer. It will suffice to mention that the work and writings of Liebig, Berzelius, Wöhler, Dumas, Gay-Lussac, Bunsen, and others had given us the leading ideas of isomerism, substitution, compound radicles, and types. Wurtz and Hofmann had just discovered the organic ammonias; Williamson that same year made known his celebrated work on the ethers; and Gerhardt discovered the acid anhydrides a year later. The newer theory of types was undergoing development by Gerhardt and his followers; the mature results were published in the fourth volume of the 'Traité de Chimie' in 1856. In this country the theory was much advanced by the writings of Odling and Williamson.

Subsequent Development of Chemistry along Two Lines.

The new era which was dawning upon us in 1851 was that of structural or constitutional chemistry, based on the doctrine of the valency of the atoms. It is well known that this conception was broached by Frankland in 1852, as the result of his investigations on the organo-metallic compounds. But it was not till 1858 that Kekulé, who had previously done much to develop the theory of types, and Couper, almost simultaneously, recognised the quadrivalent character of carbon. To attempt to give anything approaching an adequate notion of the subsequent influence of this idea on the progress of organic chemistry would be tantamount to reviewing the present condition of that subject. I imagine that no conception more prolific of results has ever been introduced into any department of science. If we glance back along the stream it will be seen that shortly after the last meeting here the course of discovery began to concentrate itself into two channels. In one we now find the results of the confluent labours of those who have regarded our science from its physical side. In the other channel is flowing the tide of discovery arising from the valency doctrine and its extension to the structure of chemical molecules. The two channels are at present fairly parallel and not far apart; an occasional explorer endeavours now and again to make a cross-cut so as to put the streams into communication. The currents in both are running very rapidly, and the worker who has embarked on one or the other finds himself hurried along at such a pace that there is hardly breathing time to step ashore and see what his neighbours are doing. It speaks well for the fertility of the conception of valency that the current in this channel is flowing with unabated vigour, although its catchment area—to pursue the metaphor—is by no means so extensive as that of the neighbouring stream.

The modern tendency to specialisation, which is a necessity arising from the large number of workers and the rapid multiplication of results, is apparently in the two directions indicated. We have one class of workers dealing with the physics of matter in relation to general chemical properties, and another class of investigators concerning themselves with the special properties of individual compounds and classes of compounds—with atomic idiosyncrasies. The workers of one class are differentiating while their colleagues are integrating. It would be nothing less than unscientific to institute a comparison between the relative merits of the two methods; both are necessary for the development of our science. All methods of attacking the unknown are equally welcomed. In some cases physical methods are available, in other cases purely chemical methods have alone been found of use. There is no antagonism, but co-operation. If the results of the two methods are sometimes at variance it is simply because we have not known how to interpret them. The physical chemist has adopted the results of the application of chemical methods of determining 'constitution,' and is endeavouring to furnish us with new weapons for attacking this same problem. The chemist who is seeking to unravel the architecture of molecules is dependent at the outset upon physical methods of determining the relative weights of his molecules. The worker who is bringing about new atomic groupings is furnishing material for the further development of generalisations from which new methods applicable to the problem of chemical structure may again be evolved. The physical chemist sometimes from the broadness of his view is apt to overlook or to minimise the importance of chemical individuality. On the other hand the chemist who is studying the numberless potentialities of combination resident in the atoms, and who has grasped to the full extent their marvellous individualities, is equally liable to forget that there are connecting relationships as well as specific differences in the properties of elements and compounds. These are but the mental traits—the unconscious bias engendered by the necessary specialisation of work to which I have referred, and which is observable in every department of scientific labour.

The Present State of Structural Chemistry.

The success attending the application of the doctrine of valency to the compounds of carbon has helped its extension to all compounds formed by other elements, and the student of the present day is taught to use structural formulæ as the A B C of his science. It is, I think, generally recognised among chemists that this doctrine in its present state is empirical, but it does not appear to me that this point is sufficiently insisted upon in chemical teaching. I do not mean to assert that for the last thirty years chemists have been pursuing a phantom; neither do I think that we should be justified in applying to this doctrine the words applied to its forerunner, the 'types' of Gerhardt, by Lothar Meyer, who says that these 'have rendered great service in the development of the science, but they can only be regarded as a part of the scaffolding which was removed when the erection of the system of organic chemistry had made sufficient progress to be able to dispense with it.'[1] It appears to me, on the contrary, that there is a physical reality underlying the conception of valency, if for no other reason because of the conformability of this property of the atoms to the periodic law. But the doctrine as it stands is empirical in so far that it is only representative and not explanatory. Frankland and Kekulé have given us a great truth, but its very success is now making it more and more obvious that it is a truth which is pressing for further development from the physical side. If we are asked why CO exists, and why CH_2 and CCl_2 do not, together with innumerable similar questions which the inquisitive mind will raise, we get no light from this doctrine. If any over-sanguine disciple goes so far as to assert that all the possible compounds of the elements indicated by their valency are capable of existence, and will sooner or later be prepared, he will, I imagine, find himself rapidly travelling away from the region of fact.

There is something to be reckoned with besides valency. The one great desideratum of modern chemistry is unquestionably a physical or mechanical interpretation of the combining capacities of the atoms. Attempts at the construction of such theories have been made, but thus far only in a tentative way, and these views cannot be said to have yet come within the domain of practical chemical politics. I have in mind, among other suggestions, the dynamical theory of van 't Hoff published in 1881,[2] the theory of electric charges on the atoms broached by Johnstone Stoney in 1874, and so ably advocated by the late Professor v. Helmholtz in his Faraday lecture in 1881, and the electric polar theory of Victor Meyer and Riecke, published in 1888.[3]

Pending the rationalisation of the doctrine of valency its promulgation must continue in its present form. Its services in the construction of rational formulæ,

[1] *Modern Theories of Chemistry*, p. 194.

[2] *Ansichten über die organische Chemie.*

[3] 'Einige Bemerkungen über den Kohlenstoffatom und die Valenz,' *Ber.*, 21, pp. 946, 1620

especially within the limits of isomerism, have been incalculable. It is the ladder by which we have climbed to the present brilliant achievements in chemical synthesis, and we are not in a position to perform the ungracious task of kicking it away. In recalling attention to its weaknesses I am only putting myself in the position of the physician who diagnoses his patient's case with the ulterior object of getting him strengthened. There can be no doubt that renewed vitality has been given to the doctrine by the conceptions of tautomerism and desmotropy, formulated by Conrad Laar in 1885, and by Paul Jacobson in 1887. The importance of these ideas is becoming more evident with the advancement of chemical discovery. Any attempt to break down the rigidly statical conception of our structural formulæ appears to me to be a step in the right direction. Then, again, I will remind you of the prolific development of the doctrine in the hands of Le Bel and van 't Hoff by the introduction of the stereochemical hypothesis in 1874—unquestionably the greatest advance in structural chemistry since the recognition of the quadrivalent character of the carbon atom. If evidence be required that there is a physical reality underlying the conception of valency, we need only point to the close accordance of this notion of the asymmetric carbon atom with the facts of so-called 'physical isomerism' and the splendid results that have followed from its introduction into our science, especially in the field of the carbohydrates through the investigations of Emil Fischer and his pupils. In other directions the stereochemical hypothesis has proved to be a most suggestive guide. It was applied by Professor v. Baeyer in 1885[1] to explain the conditions of stability or instability of certain atomic groupings, such as the explosiveness of polyacetylene compounds and the stability of penta- and hexa-cyclic systems. Again, in 1888 this eminent chemist showed its fertility in a series of brilliant researches upon benzene derivatives.[2] Nor can I omit to mention the great impetus given in this field by the classical work of Wislicenus, who in 1887 applied the hypothesis to unsaturated compounds and to cyclic systems with remarkable success.[3] Quite recently Victor Meyer and J. Sudborough have shown that the ability of certain derivatives of benzoic and naphthoic acids to form ethers is governed by stereochemical considerations.[4] But I must avoid the temptation to enlarge upon this theme because the whole subject has been recently brought together by C. A. Bischoff in his 'Handbuch der Stereochemie' (Frankfurt, 1893–94), a work to which all who are interested in the subject will naturally turn for reference.

While the present advanced state of structural chemistry may thus be looked upon as the outcome of the conceptions of Frankland and Kekulé, it may be well to bear in mind that the idea of structure is not *necessarily* bound up with the hypothesis of valency in its present form. Indeed, some advance had been made in representing 'constitution,' especially by Kolbe, before the formal introduction of this hypothesis. The two ideas have grown up together, but the experimental evidence that in any molecule the atoms are grouped together in a particular way is really independent of any theory of valency. It is only after this evidence has been acquired, either by analysis or synthesis, that we proceed to apply the hypothesis in building up the structural formula. It is of course legitimate to assume the truth of the hypothesis, and to endeavour by its use to convert an empirical into a rational formula; but this method generally gives us a choice of formulæ from which the true one can only be selected by further experimental investigation. Even within the narrower limits of isomerism it is by no means certain that all the modifications of a compound indicated by hypothesis are actually capable of existence. There is, for example, evidence that some of the 'position isomerides' among the derivatives of mono- and polycyclic compounds are too unstable to exist; a fact which in itself is sufficient to indicate the necessity for a revision and extension of our notions of valency. Thus, by way of illustration, there is nothing in the hypothesis to indicate why orthoquinones of the benzene series should not be capable of existence; yet it is a fact that in spite of all efforts such compounds

[1] *Ber.*, **18**, 2277. [2] *Ann.*, **137**, 158, and subsequent papers.
[3] *Ueber die räumliche Anordnung der Atome in organischen Molekülen*, &c.
[4] *Ber.*, **27**, 510, 1580, 3146, and **28**, 182, 1254.

have never been obtained. The conditions essential for the existence of these compounds appear to be that the hydrogen of the benzene ring should be replaced by acid substituents such as oxygen, hydroxyl, chlorine, or bromine. Under these circumstances, as Zincke has shown,[1] tetrachlor and tetrabrom-orthobenzoquinone are stable compounds. So also the interesting researches of Nietzki have proved that in such a compound as rhodizonic acid [2] orthoquinone oxygen atoms are present. But there is nothing in the doctrine of valency which leads us to suspect that these orthoquinone derivatives can exist while their parent compound resists all attempts at isolation. I am aware that it is dangerous to argue from negative evidence, and it would be rash to assert that these orthoquinones will never be obtained. But even in the present state of knowledge it may be distinctly affirmed that the methods which readily furnish an orthoquinone of naphthalene completely fail in the case of benzene, and it is just on such points as this that the inadequacy of the hypothesis becomes apparent. In other words, the doctrine fails in the fundamental requirement of a scientific theory; in its present form it gives us no power of prevision—it hints at possibilities of atomic groupings, but it does not tell us *à priori* which of these groupings are likely to be stable and which unstable. I am not without hope that the next great advance in the required direction may yet come from the stereochemical extension of the hypothesis, although the attempts which have hitherto been made to supply its deficiencies cannot but be regarded as more or less tentative.

The New Theory of Abstract Types.

I will venture, in the next place, to direct attention to a modern development of structural chemistry which will help to illustrate still further some of the points raised. For many years we have been in the habit of abstracting from our structural formulæ certain ideal complexes of atoms which we consider to represent the nucleus or type from which the compound of known constitution is derived. In other words the hypothesis of valency which was developed originally from Gerhardt's types is now leading us back to another theory of types based upon a more intimate knowledge of atomic grouping within the molecule. In some cases these types have been shown to be capable of existence; in others they are still ideal. Used in this way the doctrine of valency is most suggestive, but at the same time its lack of prevision is constantly forcing itself upon the attention of chemical investigators. The parent compound has sometimes been known before its derivatives, as in the case of ammonia, which was known long before the organic amines and amides. In other instances the derivatives were obtained before the type was isolated, as in the case of the hydrazines, which were characterised by Emil Fischer in 1875, and the hydrazo-compounds, which have been known since 1863, while hydrazine itself was first obtained by Curtius in 1887. Phenylazimide was discovered by Griess in 1864, and many representatives of this group have been since prepared; but the parent compound, hydrazoic acid, was only isolated by Curtius in 1890. Derivatives of triazole and tetrazole were obtained by Bladin in 1885; the types were isolated by this chemist and by Andreocci in 1892. Pyrazole derivatives were prepared by Knorr in 1883; pyrazole itself was not isolated till 1889, by Buchner. Alkyl nitramides were discovered by Franchimont and Klobbie many years before the typical compound, nitramide, $NO_2.NH_2$, which was isolated last year by Thiele and Lachman.[3] Examples might be multiplied to a formidable extent, but enough have been given to illustrate the principle of the erection of types, which were at first imaginary, but which have since become real. The utility of the hypothesis is undeniable in these cases, and we are justified in pushing it to its extreme limits. But no chemist, even if endowed with prophetic instinct, could have certainly foretold six years ago that the type of Griess' 'triazobenzene' would be capable of free existence, and still less that when obtained it would prove to be a strong acid. The fact, established

[1] *Ber.*, **20**, 1776. [2] *Ibid.*, **19**, 308, and **23**, 3136. [3] *Ibid.*, **27**, 1909.

by Curtius, that the group $\begin{matrix}N\\ \vdots\\ N\end{matrix}\!\!>N-$ functions in chemical molecules like the atom of chlorine is certainly among the most striking of recent discoveries. Only last year the list of nitrogen compounds was enriched by the addition of $CO(N_3)_2$, the nitrogen analogue of phosgene.[1]

These illustrations, drawn from the compounds of nitrogen, will serve to bring out the wonderful development which our knowledge of the chemistry of this element has undergone within the last few years. I might be tempted here into a digression on the general bearing of the very striking fact that an element comparatively inactive in the free state should be so remarkably active in combination, but I must keep to the main topic, as by means of these compounds it is possible to illustrate still further both the strength and the weakness of our modern conceptions of chemical structure. Consider some of the undiscovered compounds which are foreshadowed by the process of ideal abstraction of types. The azoxy-compounds contain the complex $\underset{\diagdown O \diagup}{-N-N-}$ or $\underset{O}{\overset{}{-N\overset{\cdot\cdot}{=}N-}}$. The types would be $\underset{\diagdown O \diagup}{HN-NH}$ or $\underset{O}{HN\overset{\cdot\cdot}{=}NH}$. The first of these formulæ represents the unknown dihydro-nitrous oxide. The azo-compounds are derivatives of the hypothetical diimide HN:NH. An attempt to prepare this compound from azodicarbonic acid[2] resulted in the formation of hydrazine. The diethyl-derivative may have been obtained by Harries,[3] but this is doubtful. It is at present inexplicable why compounds in which the group ·N:N· is in combination with aromatic radicles should be so remarkably stable, while the parent compound appears to be incapable of existence. The addition of two atoms of hydrogen converts this type again into a stable compound. There is nothing in the structural formulæ to indicate these facts. The amidines are stable compounds, and the so-called 'anhydro-bases,' or imidazoles, are remarkably stable; the parent compound, $HC\!\!<\!\!\begin{matrix}NH\\ NH_2\end{matrix}$, has not been obtained, while its amido-derivative, $H_2N.C\!\!<\!\!\begin{matrix}NH\\ NH_2\end{matrix}$, is the well-known substance guanidine. The isodiazo-compounds recently discovered by Schraube and Schmidt and by Bamberger[4] are possibly derivatives of the hypothetical substance $O{:}N.NH_2$, which might be named nitrosamide. Why this compound should not exist as well as nitramide is another question raised by the principle of abstract types. The carbizines were formerly regarded as derivatives of the compounds $CO\!\!<\!\!\begin{matrix}NH\\ \dot{N}H\end{matrix}$ and $CS\!\!<\!\!\begin{matrix}NH\\ \dot{N}H_2\end{matrix}$.[5] Although this structure has now been disproved the possible existence of the types has been suggested. Carbizine and thiocarbizine differ from urea and thiocarbamide only by two atoms of hydrogen. These types have not been isolated; if they are incapable of existence the current views of molecular structure give no suggestion of a reason. The diazoamides are derivatives of the hypothetical $H_2N.NH.NH_2$ or $HN{:}N.NH_2$, compounds which Curtius speaks of as the propane and propylene of the nitrogen series. The latter complex was at one time thought to exist in diazohippuramide,[6] and a biacidyl derivative of the former type has also been obtained.[7] Both these types await isolation if they are capable of existence. I may add that several attempts to convert diazoamides into dihydro-derivatives by mild alkaline reduction have led me to doubt whether this nitrogen chain can

[1] Curtius, *Ber.*, **27**, 2684. [2] Thiele, *Ann.*, **271**, 130. [3] *Ber.*, **27**, 2276.
[4] *Ibid.*, **27**, 514, 679, &c.
[5] Fischer, *Ann.*, **212**, 326; Freund and Goldsmith, *Ber.*, **21**, 2456.
[6] *Ber.* **24**, 3342. This has since been shown to be hippurazide, *i.e.*, a derivative of N_3H (*Ber.*, **27**, 779). [7] *Ibid.*, 3344.

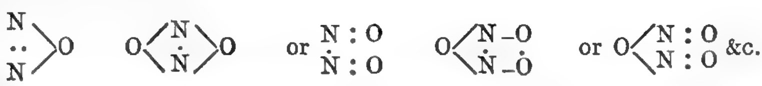
exist in combination with hydrocarbon radicles. The bisdiazoamides of H. v. Pechmann and Frobenius [1] are derivatives of the 5-atom chain $H_2N.NH.NH.NH.NH_2$ or $HN:N.NH.N:NH$, a type which hardly seems likely to be of sufficient stability to exist. The tetrazones of Emil Fischer have for their type the 4-atom chain $H_2N.N:N.NH_2$ or $H_2N.NH.NH.NH_2$, of which the free existence is equally problematical, although a derivative containing the chain $-N:N.NH.NH-$ has been obtained by Curtius.[2] Hydrazoic acid may be regarded as a derivative of triimide,

, but this type appears to be also incapable of isolation.[3] The hydrazidines or formazyls of Pinner [4] and of H. v. Pechmann,[5] have for their parent compound the hypothetical substance $H_2N.N:CH.N:NH$. In 1888 Limpricht described certain azo-compounds [6] which, if possessing the structure assigned by that author, must be regarded as derivatives of diamidotetrimide:

Both these types are at present imaginary; whether it is possible for cyclic nitrogen systems to exist we have no means of knowing—all that can be said is that they have never yet been obtained. It is possible, as I pointed out in 1890 at the Leeds meeting of the British Association, that mixed diazoamides may be derivatives of such a 4-atom ring.

Any chemist who has followed the later developments of the chemistry of nitrogen could supply numerous other instances of undiscovered types. A chapter on the unknown compounds of this element would furnish quite an exciting addition to many of those books which are turned out at the present time in such profusion to meet the requirements of this or that examining body. I have selected my examples from these compounds simply because I can claim some of them as personal acquaintances. It would be easy to make use of carbon compounds for the same purpose, but it is unnecessary to multiply details. It has frequently happened in the history of science that a well-considered statement of the shortcomings of a theory has led to its much-desired extension. This is my hope in venturing to point out one of the chief deficiencies in the structural chemistry of the present time. I am afraid that I have handled the case badly, but I am bound to confess that I am influenced by the same feelings as those which prevent us from judging an old and well-tried friend too severely.

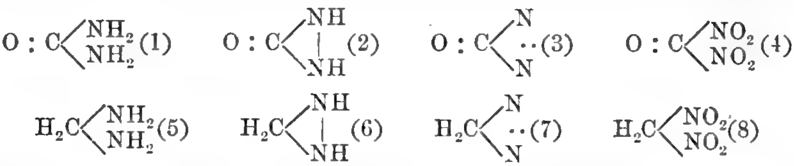
The theory of types to which we have reverted as the outcome of the study of molecular structure is capable of almost indefinite extension if, as there is good reason for doing, we replace atoms or groups by their valency analogues in the way of other atoms or groups of atoms. The facts that in cyclic systems N can replace CH (benzene and pyridine), that O, S, and NH are analogues in furfurane, thiophene, and pyrrole, are among the most familiar examples. The remarkable iodo- and iodoso-compounds recently discovered by Victor Meyer and his colleagues are the first known instances in which the trivalent atom of iodine has been shown to be the valency analogue of nitrogen in organic combination. Pushing this principle to the extreme we get further suggestions for new groupings, but, as before, no certainty of prevision. Thus, if nitrogen formed the oxide N_2O_2 the series might be written:



Of course these formulæ are more or less conjectural, being based on valency only. But since nitrous oxide is the analogue of hydrazoic acid, they hint at the

[1] *Ber.*, **27**, 898. [2] *Ibid.*, **26**, 1263 [3] Curtius, *Ber.*, **26**, 407.
[4] *Ber.*, **17**, 182. [5] *Ibid.*, **25**, 3175. [6] *Ibid.*, **21**, 3422.

possibility of such compounds as $HN\langle{}^{N}_{N}\rangle NH$, &c. If a student produced a set of formulæ corresponding to the above, in which NH had been substituted for O, and asked whether they did not indicate the existence of a whole series of unknown hydrogen compounds of nitrogen, we should probably tell him that his notions of chemical structure had run wild. At the same time I am bound to admit that it would be very difficult, if not impossible, to furnish him with satisfactory reasons for believing that such groupings are improbable. Compare again the series:



The first is urea; the second, third, fourth, fifth (methylene diamine), and sixth are unknown; the seventh is the remarkably interesting diazomethane discovered last year by H. v. Pechmann.[1] The last compound, dinitromethane, is known in the form of its salts, but appears to be incapable of existence in the free state. There is nothing expressed or implied in the existing theory of chemical structure to explain why dinitromethane is unstable while trinitromethane is stable, and mono- and tetranitromethane so stable as to admit of being distilled without decomposition. Chemists will form their own views as to the possibility or impossibility of such a series as this being completed. Whether there would be a concordance of opinion I will not venture to say; but any chemist who expressed either belief or disbelief with regard to any special member would, I imagine, have great difficulty in giving a scientific reason for the faith which is in him. At the most, he would have only the very unsafe guide of analogy to fall back upon. Perhaps by the time the British Association holds its next meeting at Ipswich it will have become possible to prove that one particular configuration of certain atoms is possible and another configuration impossible. Then will have been achieved that great advance for which we are waiting—the reunion of the two streams into which our science began to diverge shortly after the last Ipswich meeting.

The present position of structural chemistry may be summed up in the statement that we have gained an enormous insight into the anatomy of molecules, while our knowledge of their physiology is as yet in a rudimentary condition. In the course of the foregoing remarks I have endeavoured to indicate the direction in which our theoretical conceptions are most urgently pressing for extension. It is, perhaps, as yet premature to pronounce an opinion as to whether the next development is to be looked for from the stereochemical side; but it is not going too far to express once again the hope that the geometrical representation of valency will give us a deeper insight into the conditions which determine the stability of atomic configurations. The speculations of A. v. Baeyer, Wislicenus, Victor Meyer, Wunderlich, Bischoff, and others have certainly turned the attention of chemists towards a quarter from which a new light may eventually dawn.

The Progress of Synthetical Chemistry.

If, in my earnest desire to see the foundations of structural chemistry made more secure, I may have unwittingly given rise to the impression that I am depreciating its services as a scientific weapon, let me at once hasten to make amends by directing attention to the greatest of its triumphs, the synthesis of natural products, *i.e.*, of compounds which are known to be produced by the vital processes of animals and plants.

Having been unable to find any recent list of the natural compounds which have been synthesised, I have compiled a set of tables which will, I hope, see the

[1] *Ber.*, 27, 1888.

light at no very distant period. According to this census we have now realised about 180 such syntheses. The products of Bacteria have been included in the list because these compounds are the results of vital activity in the same sense that alcohol is a product of the vital activity of the yeast plant. On the other hand the various uro-compounds resulting from the transformation in the animal economy of definite chemical substances administered for experimental purposes have been excluded, because I am confining my attention to natural products. Of course the importance of tracing the action of the living organism on compounds of known constitution from the physiological point of view cannot be overestimated. Such experiments will, without doubt, in time shed much light on the working of the vital laboratory.

The history of chemical synthesis has been so thoroughly dealt with from time to time that I should not have ventured to obtrude any further notice of this subject upon your patience were it not for a certain point which appeared to me of sufficient interest to merit reconsideration. It is generally stated that the formation of urea from ammonium cyanate by Wöhler in 1828 was the first synthesis of an organic compound. There can be no doubt that this discovery, which attracted much attention at the time, gave a serious blow to the current conceptions of organic chemistry, because urea was so obviously a product of the living animal. It will be found, however, that about the same time Henry Hennell, of Apothecaries' Hall, had really effected the synthesis of alcohol—that is to say, had synthesised this compound in the same sense that Wöhler had synthesised urea. The history is soon told. In 1826 Hennell (through Brande) communicated a paper to the Royal Society which appears in the 'Philosophical Transactions' for that year.[1] In studying the compounds produced by the action of sulphuric acid on alcohol, and known as 'oil of wine,' he obtained sulphovinic acid, which had long been known, and gave fairly good analyses of this acid and of some of its salts, while expressing in the same paper very clear notions as to its chemical nature. Having satisfied himself that sulphovinic acid is a product of the action in question, he then proceeded to examine some sulphuric acid which had absorbed eighty times its volume of olefiant gas, and which had been placed at his disposal for this purpose by Michael Faraday. From this he also isolated sulphovinic acid. In another paper, communicated to the Royal Society in 1828,[2] he proves quantitatively that when sulphovinic acid is distilled with sulphuric acid and water the whole of the alcohol and sulphuric acid which united to form the sulphovinic acid are recovered. In the same paper he shows that he had very clear views as to the process of etherification. Hennell's work appears to have been somewhat dimmed by the brilliancy of his contemporaries who were labouring in the same field; but it is not too much to claim for him, after the lapse of nearly seventy years, the position of one of the pioneers of chemical synthesis. Of course in his time the synthesis was not complete, because he did not start from inorganic materials. The olefiant gas used by Faraday had been obtained from coal-gas or oil-gas. Moreover, in 1826–1828 alcohol was not generally regarded as a product of vital activity, and this is, no doubt, the reason why the discovery failed to produce the same excitement as the formation of urea. But the synthesis of alcohol from ethylene had, nevertheless, been accomplished, and this hydrocarbon occupied at that time precisely the same position as ammonium cyanate. The latter salt had not then been synthesised from inorganic materials, and the formation of urea, as Schorlemmer points out,[3] was also not a complete synthesis. The reputation of Wöhler, the illustrious friend and colleague of the more illustrious Liebig, will lose not a fraction of its brilliancy by the raising of this historical question. Science recognises no distinction of nationality, and the future historian of synthetical chemistry will not begrudge the small niche in the temple of Fame to which Hennell is entitled.

[1] 'On the Mutual Action of Sulphuric Acid and Alcohol, with Observations on the Composition and Properties of the resulting Compound,' *Phil. Trans.*, 1826, p. 240.

[2] 'On the Mutual Action of Sulphuric Acid and Alcohol, and on the Nature of the Process by which Ether is formed,' *Phil. Trans.*, 1828, p. 365.

[3] *The Rise and Development of Organic Chemistry*, p. 195.

Like many other great discoveries in science, the artificial formation of natural products began, as in the case of alcohol and urea, with observations arising from experiments not primarily directed to this end. It was not till the theory of chemical structure had risen to the rank of a scientific guide that the more complicated syntheses were rendered possible by more exact methods. We justly credit structural chemistry with these triumphant achievements. In arriving at such results any defects in the theory of structure are put out of consideration because—and this point must never be lost sight of—all doubt as to the possibility of this or that atomic grouping being stable is set aside at the outset by the actual occurrence of the compound in nature. The investigator starts with the best of all assurances. From the time of Wöhler and Hennell the course of discovery in this field has gone steadily on. The announcement of a new synthesis has ceased to produce that excitement which it did in the early days when the so-called 'organic' compounds were regarded as products of a special vital force. The interest among the uninitiated now rises in proportion to the technical value of the compound. The present list of 180 odd synthetical products comprises, among the latest discoveries, gentisin, the colouring-matter of the gentian root (*Gentiana lutea*), which has been prepared by Kostanecki and Tambor, and caffeine, synthesised by Emil Fischer and Lorenz Ach, starting from dimethylurea and malonic acid.

I have allowed myself no time for those prophetic flights of the imagination which writers on this subject generally indulge in. When we know more about the structure of highly complex molecules, such as starch and albumin, we shall probably be able to synthesise these compounds. It seems to me more important just at present to come to an understanding as to what is meant by an organic synthesis. There appears to be an impression among many chemists that a synthesis is only effected when a compound is built up from simpler molecules. If the simpler molecules can be formed directly from their elements, then the synthesis is considered to be complete. Thus urea is a complete synthetical product, because we can make hydrogen cyanide from its elements: from this we can prepare a cyanate, and finally urea. In dictionaries and text-books we find synthetical processes generally separated from modes of formation, and the latter in their turn kept distinct from methods of preparation. The distinction between formation and preparation is obviously a good one, because the latter has a practical significance for the investigator. But the experience gained in drawing up the tables of synthesised compounds, to which I have referred, has resulted in the conclusion that the terms 'synthesis' and 'mode of formation' have been either unnecessarily confused or kept distinct without sufficient reason, and that it is impossible now to draw a hard-and-fast line between them. Some recent writers, such, for example, as Dr. Karl Elbs, in his admirable work on this subject,[1] have expanded the meaning of the word synthesis so as to comprise generally the building up of organic molecules by the combination of carbon with carbon, without reference to the circumstance whether the compound occurs as a natural product or not. But although this definition is sufficiently wide to cover the whole field of the production of carbon compounds from less complex molecules, it is in some respects too restricted, because it excludes such well-known cases as the formation of hydrogen cyanide from its elements, or of urea from ammonium cyanate. I should not consider the discussion of a mere question of terminology of sufficient importance to occupy the attention of this Section were it not for a matter of principle, and that a principle of the very greatest importance, which I believe to be associated with a clear conception of chemical synthesis. The great interest of all work in this field arises from our being able, by laboratory processes, to obtain compounds which are also manufactured in nature's laboratory—the living organism. It is in this direction that our science encroaches upon biology through physiology. Now, if we confine the notion of synthesis to the building up of molecules from simpler molecules or from atoms, we exclude one of nature's

[1] *Die synthetischen Darstellungsmethoden der Kohlenstoffverbindungen.* Leipzig, 1889.

methods of producing many of these very compounds which we claim to have synthesised. There can be no manner of doubt that a large proportion, if not a majority, of the natural products which have been prepared artificially are not synthesised by the animal or plant in the sense of building up at all. They are the results of the breaking down—of the degradation—of complex molecules into simpler ones. I urge, therefore, that if in the laboratory we can arrive at one of these products by decomposing a more complex molecule by means of suitable reagents, we have a perfect right to call this a synthesis, provided always that the more complex molecule, which gives us our compound, can be in its turn synthesised, by no matter how many steps, from its constituent atoms. Thus oxalic acid has been directly synthesised from carbon dioxide by Kolbe and Drechsel by passing this gas over potassium or sodium amalgam heated to 360°. Whether the plant makes oxalic acid directly out of carbon dioxide we cannot at present state; if it does it certainly does not employ Kolbe and Dreschel's process. On the other hand this acid may, for all that is known, exist in the plant as a product of degradation. Many more complex acids, such as citric and tartaric, break down into oxalic acid when fused with potash. Both citric and tartaric acids can now be completely synthesised; therefore the formation of oxalic acid from these by potash fusion is a true synthesis.

The illustration given will make clear the point which I am urging. The distinction between a synthesis and a mode of formation vanishes when we can obtain a compound by the breaking down of a more complex molecule in all those cases where the latter can be completely built up. If we do not expand the meaning of synthesis so as to comprise such cases we are simply shutting the door in Nature's face. It must be borne in mind that the actual yield of the compound furnished by the laboratory process does not come into consideration, because it may be generally asserted that in most cases the artificial processes are not the same as those which go on in the animal or plant. The information of real value to the physiologist which these syntheses give is the suggestion that such or such a compound may possibly result from the degradation of this or that antecedent compound, and not from a process of building up from simpler molecules.

The Bearing of Chemical Synthesis on Vital Chemistry.

With these views—the outcome of structural chemistry—the chemist and physiologist may join hands and move fearlessly onwards towards the great mystery of vital chemistry. In considering the results of organic synthesis two questions always arise as it were spontaneously: How does nature produce these complicated molecules without the use of strong reagents and at ordinary temperatures? What bearing have our laboratory achievements on the mechanism of vitality? The light shed upon these questions by experimental investigation has as yet flickered only in fitful gleams. We are but dwellers in the outer gates, waiting for the guide who is to show us the bearing of modern research on the great problem which confronts alike the physicist, the chemist, and the biologist. The chemical processes that go on in the living organism are complex to an extent that is difficult to realise. Of the various compounds of animal or vegetable origin that have been produced synthetically some are of the nature of waste products, resulting from metabolic degradation; others are the result of zymolytic action within the organism; and others, again, are secondary products arising from the action of associated Bacteria, the relationship between the Bacteria and their host being as yet imperfectly understood. The answer to the question how nature produces complicated organic molecules will be much facilitated when the physiologist, by experiment and observation, shall have made possible a sound classification of these synthetical products based on their mode of origination in the organism.

The enlargement of the definition of organic synthesis which I have advocated has been rendered necessary by the consideration of certain questions which have arisen in connection with the present condition of chemical discovery in this field. What evidence is there that any one of the 180 compounds which have been prepared artificially is produced in the organism by a direct process of building up? Is not the opposite view quite as probable? May they not, from the simplest to the most complex, be products of the degradation of still more complex molecules? I venture to suggest—not without some temerity lest our colleagues of Sections I and K should treat me as an intruder—that this view should be given a fair trial. I am aware that the opposite view, especially as regards plant assimilation, has long been held, and especially since 1870, when v. Baeyer advanced his celebrated theory of the formic aldehyde origin of carbohydrates. It is but natural to consider that the formation of a complex molecule is the result of a building-up process. It must be remembered, however, that in the living organism there is always present a compound or mixture, or whatever we like to call it, of a highly complex proteid nature, which, although at present indefinite from the purely chemical point of view, is the essence of the vitality. Of course I refer to what biologists have called protoplasm. Moreover, it is perhaps necessary to state what is really nothing more than a truism, viz., that protoplasm is present in and forms a part of the organism from the very beginning of its existence—from the germ to the adult, and onwards to the end of life. Any special chemical properties pertaining to protoplasm are inseparable from the animal or plant until that period arrives which Kekulé has hinted at when we shall be able to 'build up the formative elements of living organisms' in the laboratory.[1] But here I am afraid I am allowing the imagination to take a flight which I told you a few minutes ago that time would not admit of.

The view that requires pushing forward into a more prominent position than it has hitherto occupied is that all the chemical transformations in the organism—at any rate all the primary changes—are made possible only by the antecedent combination of the substances concerned with living protoplasmic materials. The carbon dioxide, water, &c., which the plant absorbs must have formed a compound or compounds with the protoplasmic material of the chloroplasts before starch, or sugar, or cellulose can be prepared. There is, on this view, no such process as *the direct combination* of dead molecules to build up a complex substance. Everything must pass through the vital mill. The protoplasmic molecule is vastly more complex than any of the compounds which we have hitherto succeeded in synthesising. It might take up and form new and unstable compounds with carbon dioxide or formic aldehyde, or sugar, or anything else, and our present methods of investigation would fail to reveal the process. If this previous combination and, so to speak, vitalisation of dead matter actually occurs, the appearance of starch as the first visible product of assimilation, as taught by Sachs, or the formation of a 12-carbon-atom sugar as the first carbohydrate, as shown by the recent researches of Horace Brown and G. H. Morris, is no longer matter for wonderment. The chemical equations given in physiological works are too purely chemical; the physiologists have, I am afraid, credited the chemists with too much knowledge—it would appear as though their intimate familiarity with vital processes had led them to undervalue the importance of their prime agent. In giving expression to these thoughts I cannot but feel that I am treating you to the strange spectacle of a chemist pleading from the physiologists for a little more vitality in the chemical functions of living organisms. The future development of vital chemistry rests, however, with the chemist and physiologist conjointly; the isolation, identification, and analysis of the products of vital activity, which has hitherto been the task of the chemist, is only the preliminary work of physiological chemistry leading up to chemical physiology.

Protoplasmic Theory of Vital Synthesis.

The supposition that chemical synthesis in the organism is the result of the combination of highly complex molecules with simpler molecules, and that the unstable compounds thus formed then undergo decomposition with the formation of new products, may be provisionally called the protoplasmic theory of vital synthesis. From this standpoint many of the prevailing doctrines will have to

[1] *Nature*, vol. xviii. p. 212.

be inverted, and the formation of the more complex molecules will be considered to precede the synthesis of the less complex. It may be urged that this view simply throws back the process of vital synthesis one stage and leaves the question of the origin of the most complex molecules still unexplained. I grant this at once; but in doing so I am simply acknowledging that we have not yet solved the enigma of life. We are in precisely the same position as is the biologist with respect to abiogenesis, or the so-called 'spontaneous generation.' To avoid possible misconception let me here state that the protoplasmic theory in no way necessitates the assumption of a special 'vital force.' All that is claimed is a peculiar, and at present to us mysterious, power of forming high-grade chemical combinations with appropriate molecules. It is not altogether absurd to suppose that this power is a special property of nitrogen in certain forms of combination. The theory is but an extension of the views of Kühne, Hoppe-Seyler, and others respecting the mode of action of enzymes. Neither is the view of the degradational origin of synthetical products in any way new.[1] I merely have thought it desirable to push it to its extreme limit in order that chemists may realise that there is a special chemistry of protoplasmic action, while the physiologists may exercise more caution in representing vital chemical transformations by equations which are in many cases purely hypothetical, or are based on laboratory experiments which do not run parallel with the natural process. The chemical transformations which go on in the living organism are thus referred back to a peculiarity of protoplasmic matter, the explanation of which is bound up with the inner mechanism of the process of assimilation. If, as the protoplasmic theory implies, there must be combination of living protoplasm with appropriate compounds before synthesis is possible, then the problem resolves itself into a determination of the conditions which render such combination possible—*i.e.*, the conditions of assimilation. It may be that here also light will come from the stereochemical hypothesis. The first step was taken when Pasteur found that organised ferments had the power of discriminating between physical isomerides; a similar selective power has been shown to reside in enzymes by the researches of Emil Fischer and his coadjutors. Fischer has quite recently expressed the view that the synthesis of sugars in the plant is preceded by the formation of a compound of carbon dioxide, or of formic aldehyde, with the protoplasmic material of the chloroplast, and similar views have been enunciated by Stohmann. The question has further been raised by van 't Hoff, as well as by Fischer, whether a stereochemical relationship between the living and dead compounds entering into combination is not an absolutely essential condition of all assimilation. The settlement of this question cannot but lead us onwards one stage towards the solution of the mystery that still surrounds the chemistry of the living organism.

Recent Discoveries of Gaseous Elements.

The past year has been such an eventful one in the way of startling discoveries that I must ask indulgence for trespassing a little further upon the time of the Section. It was only last year at the Oxford meeting of the British Association that Lord Rayleigh and Prof. Ramsay announced the discovery of a gaseous constituent of the atmosphere which had up to that time escaped detection. The complete justification of that announcement is now before the world in the paper recently published in the 'Philosophical Transactions' of the Royal Society. The history of this brilliant piece of work is too recent to require much recapitulation. I need only remind you how, as the result of many years' patient determinations of the density of the gases oxygen and nitrogen, Lord Rayleigh established the fact that atmospheric nitrogen was heavier than nitrogen from chemical sources, and

[1] See, *e.g.*, Vines' *Lectures on the Physiology of Plants*, pp. 145, 218, 227, 233, and 234. Practically all the great classes of synthetical products are regarded as the results of the destructive metabolism of protoplasm. A special plea for protoplasmic action has also been urged, from the biological side, by W. T. Thiselton-Dyer, *Journ. Chem. Soc.*, 1893; *Trans.*, pp. 680-681.

was then led to suspect the existence of a heavier gas in the atmosphere. He set to work to isolate this substance, and succeeded in doing so by the method of Cavendish. In the meantime Prof. Ramsay, quite independently, isolated the gas by removing the nitrogen by means of red-hot magnesium, and the two investigators then combining their labours, followed up the subject, and have given us a memoir which will go down to posterity among the greatest achievements of an age renowned for its scientific activity.

The case in favour of argon being an element seems to be now settled by the discovery that the molecule of the gas is monatomic, as well as by the distinctness of its electric spark spectrum. The suggestion put forward soon after the discovery was announced, that the gas was an oxide of nitrogen, must have been made in complete ignorance of the methods by which it was prepared. The possibility of its being N_3 has been considered by the discoverers and rejected on very good grounds. Moreover, Peratoner and Oddo have been recently making some experiments in the laboratory of the University of Palermo with the object of examining the products of the electrolysis of hydrazoic acid and its salts. They obtained only ordinary nitrogen, not argon, and have come to the conclusion that the anhydride $N_3.N_3$ is incapable of existence, and that no allotropic form of nitrogen is given off. It has been urged that the physical evidence in support of the monatomic nature of the argon molecule, viz., the ratio of the specific heats, is capable of another interpretation—that argon is in fact an element of such extraordinary energy that its atoms cannot be separated, but are bound together as a rigid system which transmits the vibrational energy of a sound-wave as motion of translation only. If this be the state of affairs we must look to the physicists for more light. So far as chemistry is concerned, this conception introduces an entirely new set of ideas, and raises the question of the monatomic character of the mercury molecule which is in the same category with respect to the physical evidence. It seems unreasonable to invoke a special power of atomic linkage to explain the monatomic character of argon, and to refuse such a power in the case of other monatomic molecules, like mercury or cadmium. The chemical inertness of argon has been referred also to this same power of self-combination of its atoms. If this explanation be adopted it carries with it the admission that those elements of which the atoms composing the molecule are the more easily dissociated should be the more chemically active. The reverse appears to be the case if we bear in mind Victor Meyer's researches on the dissociation of the halogens, which prove that under the influence of heat the least active element, iodine, is the most easily dissociated. On the whole, the attempts to make out that argon is polyatomic by such forced hypotheses cannot at present be considered to have been successful, and the contention of the discoverers that its molecule is monatomic must be accepted as established.

In searching for a natural source of combined argon Professor Ramsay was led to examine the gases contained in certain uranium and other minerals, and by steps which are now well known he has been able to isolate helium, a gas which was discovered by means of the spectroscope in the solar chromosphere by Professor Norman Lockyer in 1868. In his address to the British Association in 1872[1] the late Dr. W. B. Carpenter said:—

'But when Frankland and Lockyer, seeing in the spectrum of the yellow solar prominences a certain bright line not identifiable with that of any known terrestrial flame, attribute this to a hypothetical new substance which they propose to call helium, it is obvious that their assumption rests on a far less secure foundation, until it shall have received that verification which, in the case of Mr. Crookes' researches on thallium, was afforded by the actual discovery of the new metal, whose presence had been indicated to him by a line in the spectrum not attributable to any substance then known.'

It must be as gratifying to Professor Lockyer as it is to the chemical world at large to know that helium may now be removed from the category of solar myths and enrolled among the elements of terrestrial matter. The sources, mode

[1] *Reports*, 1872, p. lxxiv.

of isolation, and properties of this gas have been described in the papers recently published by Professor Ramsay and his colleagues. Not the least interesting fact is the occurrence of helium and argon in meteoric iron from Virginia, as announced by Professor Ramsay in July.[1] Like argon, helium is monatomic and chemically inert so far as the present evidence goes. The conditions under which this element exists in cleveite, uraninite, and the other minerals have yet to be determined.

Taking a general survey of the results thus far obtained, it seems that two representatives of a new group of monatomic elements characterised by chemical inertness have been brought to light. Their inertness obviously interposes great difficulties in the way of their further study from the chemical side; the future development of our knowledge of these elements may be looked for from the physicist and spectroscopist. Professor Ramsay has not yet succeeded in effecting a combination between argon or helium and any of the other chemical elements. M. Moissan finds that fluorine is without action on argon. M. Berthelot claims to have brought about a combination of argon with carbon disulphide and mercury, and with 'the elements of benzene, . . . with the help of mercury,' under the influence of the silent electric discharge. Some experiments which I made last spring with Mr. R. J. Strutt with argon and moist acetylene submitted to the electric discharge, both silent and disruptive, gave very little hope of a combination between argon and carbon being possible by this means. The coincidence of the helium yellow line with the D_3 line of the solar chromosphere has been challenged, but the recent accurate measurements of the wave-length of the chromospheric line by Prof. G. E. Hale, and of the line of terrestrial helium by Profs. Runge and Paschen, leave no doubt as to their identity. Both the solar and terrestrial lines have now been shown to be double. The isolation of helium has not only furnished another link proving community of matter, and, by inference, of origin between the earth and sun, but an extension of the work by Professor Norman Lockyer, M. Deslandres, and Mr. Crookes, has resulted in the most interesting discovery that a large number of the lines in the chromospheric spectrum, as well as in certain stellar spectra, which had up to the present time found no counterparts in the spectra of terrestrial elements can now be accounted for by the spectra of gases contained with helium in these rare minerals. The question now confronts us, Are these gases members of the same monatomic inert group as argon and helium? Whether, and by what mechanism, a monatomic gas can give a complicated spectrum is a physical question of supreme interest to chemists, and I hope that a discussion of this subject with our colleagues of Section A will be held during the present meeting. That mercury is capable under different conditions of giving a series of highly complex spectra can be seen from the memoir by J. M. Eder and E. Valenta, presented to the Imperial Academy of Sciences of Vienna in July 1894. With respect to the position of argon and helium in the periodic system of chemical elements, it is, as Professor Ramsay points out, premature to speculate until we are quite sure that these gases are homogeneous. It is possible that they may be mixtures of monatomic gases, and in fact the spectroscope has already given an indication that they contain some constituent in common. The question whether these gases are mixtures or not presses for an immediate answer. I will venture to suggest that an attack should be made by the method of diffusion. If argon or helium were allowed to diffuse fractionally through a long porous plug into an exhausted vessel there might be some separation into gases of different densities, and showing modifications in their spectra, on the assumption that we are dealing with mixtures composed of molecules of different weights.[2]

[1] *Nature*, vol. lii. p. 224.

[2] The above was written before the interesting work of Profs. Runge and Paschen had become known in this country. These authors communicated papers to the Prussian Academy of Sciences on June 20 and July 11, in which they showed by the method advocated that helium from cleveite consists of two different gases (*Sitzungsberichte d. k. Preuss. Akad. d. Wissensch. z. Berlin*, 1895, xxx. and xxxiv.; also *Nature*, vol. lii. p. 520). The results were also made known by Prof. Runge at the joint meeting of Sections A and B on September 13.

The following Papers and Reports were read:—

1. *A New View of the Genesis of Dalton's Atomic Theory, derived from Original Manuscripts. By* Sir H. E. Roscoe, *F.R.S., and* Arthur Harden.

A number of previously unknown manuscript volumes in Dalton's writing have been found in the library of the Manchester Literary and Philosophical Society. These consist of laboratory note-books containing the record of Dalton's practical work from the year 1802 onwards, and the notes used by him for some of the lectures delivered at the Royal Institution, London, in 1810.

The examination of these volumes has cast an unexpected light on the genesis of the atomic theory, and the relation in which that theory stands to the law of combination in multiple proportions. Neither in Dalton's published papers, nor in the 'New System,' was any satisfactory account to be found of the genesis of his theories, and hence the question as to whether the atomic theory was founded on an experimental knowledge of the law of combination, or whether Dalton arrived at this law as a necessary consequence of the atomic theory of matter, was not to be gathered from his own writings. The balance of evidence derived from these newly discovered documents is strongly in favour of the statement made in London by Dalton himself, in 1810, that he was led to adopt the atomic theory of chemistry in the first instance by purely physical considerations, in opposition to the view, hitherto held by chemists, that the discovery by Dalton of the fact of combination in multiple proportions led him to devise the atomic theory as an explanation.

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2. *Report on the Teaching of Science in Elementary Schools.*

See Reports, p. 228.

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3. *The Action of Nitric Oxide on some Metallic Salts. By* H. A. Auden, *B.Sc., and* G. J. Fowler, *M.Sc.*

The experiments here recorded are part of a systematic investigation into the conditions of stability of the oxides of nitrogen. They are by no means complete, but the results so far obtained appear to be of sufficient interest to warrant a preliminary notice.

The reactions of nitric oxide have so far alone been studied. The gas was prepared by Emich's method—viz., the interaction of sodium nitrite, strong sulphuric acid, and mercury. The mixture was kept in continual agitation by a specially contrived stirrer, worked by a turbine. In this way a regular stream of gas is obtained, which analysis showed to be of a high state of purity.

In order to study the action of nitric oxide upon the salts selected a weighed amount of the salt was placed in a boat contained in a Lothar Meyer constant temperature furnace. By means of a thermostat, also devised by Lothar Meyer, the temperature can be kept constant to within one degree. Temperatures above the range of an ordinary instrument were measured by means of a high temperature thermometer, constructed by Max Kaehler and Martini, of Berlin, which would give accurate readings to over 400°.

The salt was heated gradually in a stream of nitric oxide, and the phenomena noted as the temperature rose. The salt was weighed at different intervals of temperature and time. Thus it was possible to tell at what temperature reaction began, and at what point it attained a maximum velocity.

So far oxy-salts have been chiefly studied. It was thought that by comparing their behaviour under the above conditions some light might be thrown on their stability, and thence on their constitution.

One or two oxides were first examined, the results agreeing with those of Sabatier and Senderens; *e.g.*, PbO_2 forms a basic nitrate of lead: when heated in nitric oxide the action begins at 15°, but does not attain its maximum till over 130°.

MnO_2 behaves similarly, but the change is not so rapid. It attains a maximum at 216°. In neither case is any but a trace of a nitrite formed.

Silver oxide, if containing traces of moisture, yields a mixture of almost equivalent parts of silver nitrite and metallic silver at the ordinary temperature. At higher temperatures, with the dry oxide, nitrate and metallic silver are formed almost entirely.

Silver permanganate behaves, when treated with nitric oxide, very much as a compound of oxide of silver and a higher oxide of manganese might be supposed to do. It begins to be attached at the ordinary temperature, and at 80° the alteration is very rapid. The residue was found to consist of metallic silver, silver oxide, silver nitrate, and manganese dioxide. Very little, if any, manganese nitrate was formed.

Potassium permanganate is much more stable than the silver salt. It is not appreciably attacked till a temperature of over 100° is reached, and the increase in weight becomes rapid at 190°.

The residue on moistening was not alkaline, and no manganese could be dissolved out. The potassium is converted into nitrate, and the manganese into oxide.

Interesting differences were noted in the behaviour of other silver and potassium salts, notably, the chlorate and iodate.

Potassium chlorate is attacked by nitric oxide at the ordinary temperature, chlorine being evolved in considerable quantity, and nitric peroxide being formed. The gaseous product was condensed in a tube immersed in a freezing mixture, and the percentage of chlorine in the brown liquid obtained was determined. It was found to be much in defect of that required to form nitrosyl or nitroxyl chloride. So that the reaction does not consist simply in the formation of an oxychloride of nitrogen. On analysis of the residue in the boat, no chloride of potassium was found to be present. Nitrate was formed, and also a trace of perchlorate. This seems to be direct proof that in potassium chlorate the potassium and chlorine are separated.

With barium chlorate a similar reaction takes places.

With silver chlorate (prepared according to Stas's method from silver oxide) chlorine was given off, but a considerable amount of silver chloride was also formed, nearly one-third of the silver present being found as chloride. This may be due to a difference in constitution between the chlorates of silver and of potassium, or to a difference in the stability of the salts and the products of reaction.

That some difference of constitution exists between the silver and potassium salts appears to derive confirmation from the behaviour of their iodates when treated with nitric oxide.

Potassium iodate heated to 80° in nitric oxide begins to give off iodine, and the reaction becomes rapid at 110°, crystals of iodine condensing on the cool portion of the tube; no trace of iodide, however, is formed, as is shown by there being no liberation of iodine on acidifying a solution of the residue after adding some potassium iodate. The residue is not alkaline, the potassium being converted into nitrate, recognised by the evolution of ammonia when the residue is warmed with zinc dust and caustic soda.

Silver iodate, on the other hand, is stable up to a rather higher temperature than the potassium salt, and when heated above this temperature, about 110°, no trace of iodine is given off, but all the silver is converted into iodide, none being dissolved out by water, and the yellow residue being insoluble in dilute nitric acid.

The perchlorates and periodates which have been examined show themselves more stable than the corresponding chlorates and iodates.

Of the salts so far examined the chromates have shown themselves the most stable, being analogous in this respect to the sulphates.

Lead chromate was unaltered at temperatures exceeding 400°.

Silver chromate did not suffer appreciable change till above 300°. Metallic silver was found to be present in the residue as well as silver nitrate. The chromium was all converted into the sesquioxide. Some amount of nitrite of silver was also formed.

Silver sulphate is only attacked at the highest temperature of the furnace.

It was found in certain cases—*e.g.*, with lead nitrate—that the intermixture of a decomposable oxide—*e.g.*, PbO_2 or MnO_2—with the salt, caused the latter to be attacked at a temperature below that at which action begins with either the salt or oxide taken separately.

Experiments have also been in progress on the interaction of nitric oxide and various gases, but the results are not yet quite complete enough for publication.

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4. *On the Respirability of Air in which a Candle Flame has burnt until it is extinguished. By* FRANK CLOWES, *D.Sc.*

At the last meeting of the British Association the author stated the composition of artificial mixtures of nitrogen and carbon dioxide with air, which were just able to extinguish various flames. It was found that the flames of ordinary candles and lamps were extinguished by mixtures which contained on the average about 16·5 per cent. of oxygen and 83·5 per cent. of the extinctive gases. A flame of coal-gas, however, required for its extinction a mixture still poorer in oxygen, and containing 11·3 per cent. of oxygen and 88·7 per cent. of the extinctive gases. These results have since been confirmed by a different method. The method consisted in allowing the flames to burn in air enclosed over mercury until they were extinguished; the remaining extinctive atmosphere was then subjected to analysis, and its composition was found to be practically identical with that previously obtained from the artificial mixtures. An analysis of air expired from the lungs proved that it was also of the same composition as that which extinguished the flame of an ordinary candle or lamp.

The average percentage composition of expired air and of air which extinguishes a candle flame is as follows:—oxygen 16·4, nitrogen 80·5, carbon dioxide, 3·1.

Now an atmosphere of this composition is undoubtedly respirable. Physiologists state that air may be breathed until its oxygen is reduced to 10 per cent. The maximum amount of carbon dioxide which may be present is open to question, but it is undoubtedly considerably higher than 3 per cent. Dr. Haldane maintains that the above atmosphere is not only respirable, but would be breathed by a healthy person without inconvenience of any kind; he further states that no permanent injury would result from breathing such an atmosphere for some time.

The conclusion to be drawn from these facts is that an atmosphere must not be considered to be dangerous and irrespirable because the flame of an ordinary candle or oil lamp is extinguished by it. The view is very generally advanced that a man must, on no account, venture into air which extinguishes the flame of a candle or of a bundle of shavings. It will be seen that this precaution may deter one from entering an atmosphere which is perfectly safe and respirable, and from doing duty of a humane or necessary character. An atmosphere which extinguishes a coal-gas flame, however, appears to approach closely to the limit of respirability, as far as the proportion of oxygen which it contains is concerned. Hence the coal-gas flame appears to be a more trustworthy indicator of respirability than the flame of a candle or oil-lamp. Undoubtedly the candle and lamp flames should be discarded as tests of respirability of air.

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5. *The Action of Light upon the Soluble Metallic Iodides in presence of Cellulose. By* Douglas J. P. BERRIDGE, *B.A., Malvern College.*

It was shown by Cook, in 1894, that whilst potassium iodide, purified by ordinary methods, is decomposed by light, the salt is not thus affected if purified by either fusion with charcoal or crystallisation from absolute alcohol. Although this is so, the iodide is readily decomposed, even when perfectly pure, when exposed to light in the presence of cellulose, the most suitable form of this material being filter-paper, which has been extracted by hydrochloric and hydrofluoric acids. If a solution of the ordinary pure salt is sealed in a bulb and exposed to light, whilst in another bulb is placed an equal quantity of the same solution, together with pure cellulose, it is found that considerably more iodine is liberated in the latter than in the former: this difference in many cases amounting to 800 per cent. The solution not containing cellulose gives an alkaline reaction with phenolphthalein, whilst one sealed with sufficient cellulose is quite neutral: the action of the cellulose is therefore probably due to its combination with any potassium hydrate produced by the oxidation of the iodide in presence of light and moisture.

If a sheet of note-paper containing starch is saturated with a solution of potassium iodide, and exposed to light in a printing frame under a negative, it will become printed in a period varying from ten minutes to four hours, the colour of the exposed paper being pink or chocolate; this changes, however, to blue when placed in water, the alteration being doubtless due to the formation of the so-called starch iodide, for the production of which the presence of an excess of water is necessary. It was found impossible to imitate this chocolate colour by any solution of iodine: if the solution was aqueous, a blue stain was produced, whilst, if anhydrous, a brown stain resulted. At last, however, the colour of the exposed paper was obtained by the action of a very concentrated solution of potassium iodide upon paper previously coloured blue by starch iodide. This appears to show that the colour is due to the formation of potassium triiodide, or some similar compound.

The prints obtained in this manner were fixed by rapid washing in water, followed by treatment with a dilute solution of lead acetate; if subsequently sized and varnished, they appear to be quite stable.

The iodides of sodium, calcium, strontium, barium, iron, and zinc, all behave like the potassium salt; the two latter, however, yield prints difficult to see, owing to the decomposition of the salt upon the portions of the paper unexposed to the light.

Cadmium iodide differs from the other soluble metallic iodides in yielding a print which is blue, and not chocolate coloured; from which it appears that this element is alone unable to form a higher iodide.

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6. *Second Report on Quantitative Analysis by means of Electrolysis.*
See Reports, p. 235.

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7. *Report on Wave-length Tables of the Spectra of the Elements.*
See Reports, p. 273.

FRIDAY, SEPTEMBER 13.

Joint Meeting with Section A.—See p. 609.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

A discussion[1] was held in conjunction with Section K (Botany) on the Relation of Agriculture to Science. The discussion was opened by the following Papers:—

How shall Agriculture best obtain Help from Science? By Prof. R. WARINGTON, *F.R.S.*

Ordered to be printed *in extenso.*—See Reports, p. 341.

Agriculture and Science. By T. HENDRICK.

The Application of Science to Agriculture. By M. R. J. DUNSTAN.

The following Paper and Reports were read:—

1. *Work at the Agricultural Experimental Stations in Suffolk and Norfolk. By* T. B. WOOD.

Two stations were started in West Suffolk in 1893, one on the chalk at Higham, the other on a good deep loam at Lavenham—both typical soils in the county. Crops are grown at each station in rotation with various manures, and an annual report is printed and circulated among farmers of the county. Demonstrations are given on the plots on the action of manures, the methods and effects of potato spraying, &c. Expenses are borne by West Suffolk Technical Instruction Committee, and the management is under the Cambridge and Counties Agricultural Education Scheme.

In Norfolk the arrangements are different. The experiments, started in 1886, are conducted by the Chamber of Agriculture; since 1888 they have received an annual grant from the Board of Agriculture, and since 1892 one from the Technical Education Committee of the Norfolk County Council. The experiments have included manurial experiments on all the ordinary crops in the usual course of farming; the comparison of many well-known varieties of wheat and barley; the value of residues of manures, and various sheep-feeding experiments to test the value of oil in cakes very rich in oil; the comparison of the values of many popular diets; the determination of the most economical rations, &c.

Besides these experiments in the field a considerable amount of laboratory work has been done at both the county stations.

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2. *Report on the Preparation of Haloids from Pure Materials.* See Reports, p. 341.

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3. *Interim Report of the Committee on the Bibliography of Spectroscopy.* See Reports, p. 263.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *Some Remarks on Orthochromatic Photography. By* Dr. H. W. VOGEL.

My first researches on orthochromatic photography were published twenty-three years ago. These investigations were confirmed by Becquerel and were first brought under the notice of the English public by Meldola in 1874.

[1] An account of the discussion is published, and is sold at the Office, price 3*d*.

In India, in 1875, at my suggestion Colonel Waterhouse used bromide of silver collodion plates dyed with eosin. The success of his experiments demonstrates that eosin was the best optical sensitiser for collodion plates. Later Ducos de Hauron employed orthochromatic plates in his photochrome or three-colour printing process. Attout-Tailfer next introduced isochromatic gelatine dry plates dyed with eosin or its derivatives, in conjunction with an alkali. I used azaline—a mixture of quinoline blue and quinoline red—for the same purpose; whilst Eder, of Vienna, recommended erythrosin (tetra-iodo-fluorescein) as the best optical sensitiser for dry plates. In 1885 Obernetter and I showed that by the use of eoside of silver plates it was possible to dispense with a yellow screen for ordinary landscape photography. I find that the best results are obtained with a film containing 1,000 parts of collodion (containing seventeen of cotton) to three parts aurantia. The exposure required in this case is four times as long as when no yellow screen is employed. For landscapes only two parts of aurantia are necessary, and the exposure required is only two and a half times longer than without a screen. Another important factor in regard to orthochromatic plates is the action of the developer. My own results show that the impressions of the blue rays develop before those of the red and yellow, and, therefore, when using eosin dyed plates they should be developed until all the yellow parts of the picture are visible in the negative. It is usually stated that the relative value of colours in a landscape approximates more closely at sunrise and at sunset than at noon, and, therefore, that in the former case a yellow screen is unnecessary when using orthochromatic plates. This would be true were direct sunlight the only agent, but since diffused light also comes into play it is not the case, for Crova has shown that the proportion of blue rays in diffused light increases as the sun goes down, whilst the reverse holds for direct sunlight. With orthochromatic plates the results depend on (1) the colour sensitiveness of the plate; (2) the proportion of the different coloured rays in the diffused light: and this proportion, I find, varies from day to day.

I gather from Captain Abney's paper in the 'Photographic Journal' that the sensitiveness of the plates he employed for yellow rays was only $\frac{5}{7}$ths of that for blue. To this fact I attribute the unsatisfactory results he obtained. In Germany we use eosin dyed plates, the sensitiveness of which is five times greater for yellow rays than for blue rays. Such plates can be used for landscapes without a yellow screen. The prints exhibited to the Section show the comparative results obtained with ordinary plates and plates of this kind. The pictures were taken at 3 P.M.

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2. *On the Sensitising Action of Dyes on Gelatino-bromide Plates.* *By* C. H. Bothamley.

Although large numbers of dyes have been examined since Dr. H. W. Vogel's discovery in 1873, very few exert any marked effect in making gelatino-bromide plates sensitive to the less refrangible rays of the spectrum. Only cyanin and the dyes of the eosin group (including the rhodamines), with perhaps malachite green, chrysoidine, and alizarin blue, can be said to exert any useful effect.

The main points established by previous observers may be summarised as follows: (1) The dyes that act as sensitisers are readily affected by light when they are in contact with fabrics, paper, &c.; (2) in order that a dye may act as a sensitiser it must have the power of entering into intimate union with silver bromide, forming a kind of 'lake'; (3) and it must show a strong absorption band for the particular rays for which it is to sensitise. Although these statements hold good for all the dyes that are known to act as sensitisers, it is important to observe that the converse is not necessarily true. Several dyes having all these properties show no appreciable sensitising action.

Experiments by Dr. E. Vogel on the rate of fading and the sensitising action of the eosin dyes, led him to the conclusion that the order of sensitising effect coincides with the order of fading when the dyes are exposed to light. The order in which Vogel places the dyes does not, however, correspond with the order of fading as observed in dyed fabrics, and the experimental method that he used is open to criticism.

The author's observations on the fading of the various sensitisers, when exposed to light in contact with gelatin, lead him to the conclusion that, although all the sensitisers are readily affected by light, the order of sensitising effect does not necessarily correspond with the order of fading, whether the dyes belong to the same chemical group or not.

There are two chief hypotheses as to the mode in which the dyes act, namely: (1) the view held by Abney that the dye itself is oxidised by the action of light, the oxidation product remaining in contact with the silver bromide; and when the plate is treated with the developer, the latter and the oxidation product acting simultaneously on the silver bromide bring about its reduction; and (2) the view first definitely formulated by Eder, and endorsed by Vogel, namely, that the energy absorbed by the dyed silver bromide is partially used up in bringing about the chemical decomposition of the silver bromide, instead of being almost entirely converted into heat, as when absorbed by the dye alone.

The author has found that the less refrangible rays will produce a photographic image on the sensitised gelatino-bromide plates, when they are immersed in powerfully reducing solutions, such as a mixture of sodium sulphite and pyrogallol. This holds good for cyanin, the eosin dyes, the rhodamines, and quinoline red, whether the sensitiser has been added to the emulsion or has been applied to the prepared plate in the form of a bath. It is, therefore, impossible to attribute the sensitising effect to any intermediate oxidation of the dye.

Experiments with various reagents such as potassium bromide, potassium dichromate, mercuric chloride, and dilute hydrogen peroxide seem to show that the chemical nature of the latent image produced by the less refrangible rays on the specially sensitised plates is precisely the same as that of the latent image produced by the more refrangible rays in the ordinary way.

Further proof in the same direction is afforded by the fact that the effect of the sensitisers extends to the production of a visible effect by the prolonged action of light.

The balance of evidence is therefore greatly in favour of the view that the dye absorbs the particular group of rays, and, in some way which is not at all clear, hands on the energy to the silver bromide, with which it is intimately associated, and which is thereby decomposed.

For the present, for want of a better word, the phenomenon might be distinguished as *photo-catalysis,* and the sensitiser might be described as a *photo-catalytic* agent. As yet no connection can be traced between the chemical constitution and the general physical properties of a dye, and its sensitising action.

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3. *Report of the Committee on the Action of Light on Dyed Colours.*

See Reports, p. 263.

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4. *On some Stilbene Derivatives.*

By J. J. SUDBOROUGH, *D.Sc., Ph.D., F.I.C.*

The author has prepared monochloro-, methyl-chloro-, and ethyl-chloro-stilbene by the action of phosphorus pentachloride on deoxybenzoïn and on its methyl and ethyl derivatives. The monochloro-stilbene differs from that described by Zinin ('Annalen,' 149. 375), as it is a solid, which crystallises from alcohol in large colourless plates. It melts at 53°–54°, and yields additive compounds with bromine, with chlorine and with 'nitrous acid.' These, together with the corresponding compounds obtained from methyl- and from ethyl-chloro-stilbene, are described. An oily monochloro-stilbene, corresponding to that of Zinin, has also been prepared, and is being subjected to further examination in order to determine whether it is merely an impure form of the crystalline compound or a true stereo-isomeride.

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5. *Note on the Constitution of Camphoric Acid.* *By* J. J. Sudborough, *D.Sc., Ph.D., F.I.C.*

The author draws attention to the fact that, as regards its etherification, camphoric acid shows a marked resemblance to some of the polycarboxylic acids investigated by Victor Meyer and Sudborough ('Ber.,' 27, 3146), and to hemipinic acid (Wegscheider, 'Monatsheft,' 16, 75). It is thought that this resemblance may throw some light on the constitution of camphoric acid, and that at any rate it can be used as an argument for or against any formula which is brought forward. The author then considers several of the more important formulæ already suggested, and regards those of Armstrong and of Bredt as best agreeing with the behaviour of camphoric acid.

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6. *Experimental Proof of van 't Hoff's Constant, Dalton's Law, &c., for very Dilute Solutions.* *By* Dr. M. Wildermann.

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7. *The Formation and Properties of a New Organic Acid.* *By* Henry J. Horstman Fenton, *M.A.*

When tartaric acid is oxidised under certain conditions in presence of a ferrous salt a substance is produced which acts as a powerful reducing agent, and which gives a beautiful violet colour with ferric salts in presence of alkali. This substance has after considerable difficulty been isolated, and proves to be a dibasic acid having the formula $C_4H_4O_6.2H_2O$.

The constitution of this acid is now under investigation.

Heated with hydrogen iodide it gives succinic acid, racemic acid being an intermediate product. Bromine in presence of water oxidises it quantitatively to dioxytartaric acid. Heated with water it is resolved into carbon dioxide and glycollic aldehyde.

This aldehyde has been obtained as a viscid liquid, pure except for a trace of ether; and, on removing the latter by heating in a vacuum, the aldehyde undergoes polymerisation, a sweet-tasting solid gum being the result. Analysis and molecular weight determination show that this gummy substance has the formula $C_6H_{12}O_6$.

Further observations have recently been made as to the conditions under which this new acid may be obtained from tartaric acid. The presence of a *ferrous* salt is essential. Ferric, manganous, and various other salts have been tried with negative results.

If moist ferrous tartrate be exposed to the air for a short time a certain quantity of the new acid is produced, and may be indicated by the characteristic violet colour given when caustic alkali is added. The effect is much more intense if the exposure be made out of doors, and the increased result was at first attributed to some constituent of the fresh air (*e.g.*, hydrogen dioxide; ozone seems to be inoperative). But later experiments show conclusively that *light* is the cause. Air which has been purified by passing through potassium iodide and caustic potash solutions gives an effect about equal in intensity to that produced by fresh external air, if the exposure to light be the same in both cases. That *oxygen* (or some oxidising agent) is essential is shown by the fact that exposure in a vacuum, even to bright sunlight, gives a negative result.

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8. *On the Velocity of Reaction before Perfect Equilibrium takes place.* *By* Meyer Wildermann, *Ph.D.*

The solidification and the crystallisation of over-cooled liquids, as well as the melting of frozen and solidified liquids, belong to processes which occur most generally in nature; therefore it is of importance to know the velocity with which these processes take place, and to find the common equation for all of them.

1. *On the Velocity of Solidification of Over-cooled Liquids, of Solutions, and of Liquid Mixtures.*—From the experiments of Moore, made in Ostwald's laboratory,[1] the author shows that the equation $\frac{dx}{dz}=c(t_0-t)$ is to be applied for the velocity of solidification, where t is the actually existing temperature of the over-cooled liquid, t_0 the temperature, where the solid and liquid solution are in equilibrium, since beginning with the greater differences (instead of as has been done by Moore, with the smaller) t_0-t, it is easy to show that $\frac{t_0-t_{\prime}}{t_0-t_{\prime\prime}}=\frac{(dx:dz)t_{\prime}}{(dx:dz)t_{\prime\prime}}$.

2. *On the Velocity of Crystallisation of Over-cooled Liquids and Solutions.*—The same equation $\frac{dx}{dz}=c(t_0-t)$ is found to be applied for the velocity of crystallisation. Now, since the separation of the solid solvent is accompanied by evolution of heat (latent heat of melting), and the increase of the temperature of the liquid is directly proportional to the quantity of separated ice, we can, instead of the above equation, put $\frac{dt}{dz}=c'(t_0-t)$, where c' is directly proportional to the latent heat of melting, and inversely proportional to the specific heat of the liquid. Very careful measurements have been carried out. The liquid was at first over-cooled to below its freezing-point; the distance from the freezing-point was then measured on the ·01° thermometer, and the time noted by my assistant to $\frac{1}{5}$ second.

3. *On the Velocity of Melting of Solid Solvents in the Warmer Liquids and Solutions.*—For the process of melting, Newton's equation $\frac{dt}{dz}=c(t_0-t)$ for conduction is to be used; the convergence temperature is here that at which ice and liquid are in equilibrium, *i.e.*, the freezing-point; the ice plays here the part of the cooling medium, abstracting heat from the liquid. Since now the velocity of reaction takes place through the ice-surface, the velocity of reaction at a given time z will be also directly proportional to the surface of the ice present in the liquid at the time z. Our equation can therefore get the form $\frac{dt}{dz}=c'(t_0-t)O$, where O is in proportion to the surface of the ice. The liquid or solution to be investigated is at first over-cooled 1° or 1°·2 below its freezing-temperature; the ice is then crystallised. After the separation of the ice we allow the ice to rise in the beaker to the upper part of the liquid, warm the liquid to about 0°·3 or 0°·4 above the freezing-point; the liquid is then stirred, the temperature rises at first, and after reaching its maximum falls. The time is measured to $\frac{1}{5}$ second.

We have therefore investigated *two classes* of reactions before *perfect* equilibrium takes place. *The first* is where the temperature of *both* parts of the heterogeneous system is below or above the temperature of equilibrium (solidification, crystallisation). For this class we have to apply the equation $\frac{dx}{dz}=c(t_0-t)$ or $\frac{dt}{dz}=c'(t_0-t)$, which in its form, but not in its purport, is identical with Newton's equation for conduction. The *second class* is where *one* of the parts of the heterogeneous system is at the temperature of equilibrium and *the other* is above or below that of equilibrium (melting process in liquids). The velocity of these processes is regulated by Newton's law for conduction.

As we know, we have two kinds of equilibrium, *perfect* and *imperfect* equilibrium. While in the case of perfect equilibrium (for example, ice and water) at a constant pressure, the smallest change of temperature is sufficient to cause one of the parts of the heterogeneous system to disappear, in the case of imperfect equilibrium (for example, acid + alcohol, ether + water) a small change of temperature produces only a small change in the state of equilibrium, while the relation

[1] *Zeitschr. phys. Chem.*, vol. xii. p. 545.

of the quantities of the acting parts changes in one or the other direction. The velocity of reaction, before *imperfect* equilibrium takes place, formed the subject of investigation of many scientists; Vernon-Harcourt and Esson, van 't Hoff, Guldberg, and Waage, should be specially mentioned. The author finds in the case of solidification and crystallisation that the equation $\frac{dx}{dz} = c(t_0 - t)$, or $\frac{dt}{dz} = c'(t_0 - t)$ is to be applied, but would express the common equation as $\frac{dx}{dz} = f(t_0 - t)$, since the velocity of the reaction can often be complicated by other phenomena.

Let us now bring into connection the equations for the two kinds of velocity of reactions with the two kinds of equilibrium.

In the case of *imperfect* equilibrium we have, *before* the state of equilibrium is arrived at, two reactions:

$$\frac{dx}{dz} = c(A - x)(B - x) \quad \text{(alcohol + acid)}$$

$$\left(\frac{dx}{dz}\right)' = c'x'^2 \quad \text{(ether + water)},$$

and equilibrium is arrived at when $c(A - x')(B - x') = c'x'^2$, *i.e.*, both reactions take place simultaneously and *the equilibrium is a dynamic one.* In the case of *perfect* equilibrium we have *before* the equilibrium is arrived at

$$\frac{dx}{dz} = c(t_0 - t),$$

and equilibrium is arrived at when $t_0 - t = 0$ (*i.e.*, at the freezing temperature); $\frac{dx}{dz}$ therefore at the point of equilibrium equals 0, that is to say, no further reaction takes place, and *the equilibrium is a static one.*

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9. *Chemical History of Barley Plants.* *By* C. F. Cross *and* C. Smith.

Work has been carried out over a period of two years (1894 and 1895) upon crops grown on the experimental plots at Woburn. Maximum plot 6 and minimum plot 1 were investigated with regard to the furfural and permanent tissue which they contain.

A table of results is appended to the paper.

From the table we draw the following conclusions:—

1. The conditions of soil nutrition have very little influence upon the composition of the plant.

2. The *feeding value* of straws grown in wet seasons is high, and conversely the *paper-making* value of such straws is low.

3. The furfuroids are continuously assimilated to permanent tissue in a normal season, but in a dry season, on the other hand, the permanent tissue is put under contribution for nutrient material, which is ordinarily drawn from the cell contents.

Section C.—GEOLOGY.

President of the Section.—W. Whitaker, B.A., F.R.S., F.G.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

Underground in Suffolk and its Borders.

When the British Association revisits a town it is not unusual for the Sectional Presidents to refer to the addresses of their local predecessors, and to allude to the advance of their science since the former meeting. I have at all events tried to follow this course, with the sad result of having to chronicle a falling back rather than an advance in our methods of procedure; for at the meeting of 1851 all the Sectional Presidents had the wisdom not to give an address, and of all the inventions of later years I look upon the presidential address as perhaps the worst.

Had I the courage of my opinion I should not now trouble you; but an official life of over thirty-eight years has led me to do what I am told to do, and to suppress my own ideas of what is right. After all it is the fault of the Sections themselves that they should suffer the evil of addresses. They could disestablish the institution without difficulty.

On these occasions it is not usual to allude to the personal losses our science has had in the past year; but there are times when the lack of a familiar presence can hardly be passed over, and since we last met we have lost one of our most constant friends, who had served us long and well, and had been our Secretary for a far longer time than any other holder of that office. When we were at Oxford last summer none of us could have thought that it was our last meeting with William Topley.

I do not now mean to say anything on the origin or on the classification of the various divisions of the Crag and of the Drift that occur so plentifully around us, and form the staple interest of East Anglian geology. These subjects, which are the more interesting from being controversial, I leave to my brother-hammerers, and without claiming the credit of magnanimity in so doing, having said what I had to say on them in sundry Geological Survey Memoirs. The object of this address is to carry you below the surface, and to point out how much our knowledge of the geology of the county in which we meet has been advanced by workers in another field, by engineers and others in their search for water. As far as possible allusion will be made only to work in Suffolk; but we must occasionally invade the neighbouring counties.

This kind of evidence has chiefly accumulated since the meeting of the Association at Ipswich in 1851; for of the 476 Suffolk wells of which an account, with some geologic information, has been published, only 68 were noticed before that year, all but two of these being in a single paper. The notes on all these wells are now to be found in twelve Geological Survey Memoirs that refer to the county. Number alone, however, is not the only point, and many of the later records are marked by a precision and a detail rarely approached in the older ones. It should be stated that in the above and in the following numbers strict accuracy is not professed, nor is it material. A slight error in the number of the wells, one way or the other, would make practically no difference to the general conclusions.

Now let us see how these records affect our knowledge of the various geologic formations, beginning with the newest and working downward.

The Drift.

Under this head, as a matter of convenience for the present purpose, we will include everything above the Chillesford Clay. There is no need for refinement of classification, and the thin beds that come in between that clay and the Drift in some parts do not affect the evidence we have to deal with.

As a matter of fact it is only from wells that we can tell the thickness of the Drift over most of the great plateau that this formation chiefly forms; open sections through a great thickness of Drift, to its base, are rare, except on the coast.

There is often some doubt in classifying the beds, the division between Drift and Crag being sometimes hard to make in sections of wells and borings; but from an examination of the records of these Suffolk sections that pass through any part of the Drift Series (as defined above) we find that no less than 173 show a thickness of 50 feet and upward, whilst of these 34 prove no less than 100 feet of Drift, many reaching to much more. Of the two that are said to show a thickness of over 200 feet and the one other said to be more than 300 feet deep in Drift, we can hardly feel certain; but such amounts have been recorded with certainty as occurring in the neighbouring county of Essex.

These great thicknesses (chiefly consisting of Boulder Clay) show the importance of the Drift, and the impossibility of mapping the formations beneath with any approach to accuracy, on the supposition that the Drift is stripped off, as is the case in the ordinary geologic map. The records also show the varying thickness of the Drift, and how difficult it often is therefore to estimate the thickness at a given spot. Sometimes the sections seem to point to the existence of channels filled with Drift, such as are found also in Essex and in Norfolk; and it may be noted that in the northern inland part of the former county, one of these channels has been traced, though of course not continuously, for some 11 miles along the valley of the Cam, and at one place to the depth of 340 feet (or nearly 140 below sea-level), the bottom of the Drift moreover not having been reached even then. A channel of this sort seems to occur close to us, in the midst of the town of Ipswich, where, by St. Peter's, one boring has pierced 70 feet of Drift, and another 127, in ground but little above the sea-level.

As the Drift sands and gravels, that in many places occur below the Boulder Clay, often yield a fair amount of water, the proof of their occurrence and of the thickness of the overlying clay is of some practical good.

The Crag.

On this geologic division we have a less amount of information, as would be expected from the fact that it is not nearly so widespread as the Drift, and this information is confined to the Upper, or Red, Crag, the Lower, or Coralline, Crag occurring only over a very small area, and no evidence of its underground extension being given by wells.

What we learn of the Red Crag, however, is of interest, several wells having proved that it is far thicker underground than would have been supposed from what is seen where its base crops out. One characteristic, indeed, of this sandy deposit, in the many parts where it can be seen from top to bottom, is its thinness, as in such places it rarely reaches a thickness of 40 feet. But, on the other hand, wells at Hoxne seem to prove more than 60 feet of Crag, whilst at Saxmundham the formation is 100 feet thick, and at Leiston and Southwold over 140. Further north, just within the border of Suffolk, there is, at Beccles, a thickness of 80 feet of sand, or, with the overlying Chillesford Clay, a total of 95. Our underground information has, then, trebled the known thickness of the Upper Crag of Suffolk.

It has also shown that at some depth underground the colour-name is a misnomer, the shelly sands being light-coloured and not red. This is the case too with some other deposits, which owe their reddish-brown colour at the surface to peroxide of iron. Presumably the iron-salt is in a lower state of oxidation until it comes within reach of surface-actions. This seems to point to the risk of taking colour as the mark of a geologic formation.

Eocene Tertiaries.

Below the Crag there is a great gap in the geologic series, and we come to some of the lower of the Tertiary formations, about which little had been published, as regards Suffolk, before the work of the Geological Survey in the county. It seems as if the special interest in the more local Crag had led observers to neglect these beds, which had been amply noticed in other parts.

We have records of more than forty wells in Suffolk that are partly in these deposits, and of these thirty-six reach down to the Chalk, twenty giving good sections from the London Clay to the Chalk. The thickness of the Lower London Tertiaries (between those formations) thus proved varies from 30 to 79½ feet, the higher figure being much greater than anything shown at the outcrop. The greatest recorded thickness is at Leiston, where, moreover, the top 26 feet of the 79½ may belong to the uppermost and most local of the three divisions of the Series, the Oldhaven Beds, of very rare occurrence in the county. The next greatest thickness is at Southwold, where the whole has been classed as Reading Beds (the persistent division), though here and elsewhere it is possible that the underlying Thanet Beds are thinly represented. It is noteworthy that at both these places, where the Lower London Tertiaries are thick, they are also at a great depth, beginning at 252½ and 218 feet respectively, which looks as if, like the Crag, they thickened in their underground course away from the outcrop.

The important evidence given by these wells, however, is not as regards thickness; it is to show the underground extent of the older Tertiary beds, beneath the great sheet of Crag and Drift that prevents them from coming to the surface north-eastward from the neighbourhood of Woodbridge. It is clear that over this large tract we can know nothing of the beds beneath the Crag otherwise than from wells and borings; and, until these were made, our older geologic maps cut off the older Tertiary beds far south of the parts to which we now know that they reach, though hidden from our sight. No one, for instance, would have imagined many years ago that at Southwold the Chalk would not be touched till a boring had reached the depth of 323 feet, or some 280 below sea-level, or that at Leiston those figures would be about 297 and 240.

It is from calculations based on the levels of the junction of the Chalk and the Tertiary beds in many wells that the line engraved on the Geological Survey map as the probable boundary of the latter beds under the Crag and Drift has been drawn. From what has gone before, however, as to the great irregularity in the thickness of the Drift, it is clear that this line must be taken only as approximate, and open to correction as further evidence is got; albeit the junction of the Chalk and the Tertiary beds is found to be here, as elsewhere, fairly even, along an inclined plane that sinks toward the coast.

Cretaceous Beds.

Though the *Chalk* is reached by very many wells, yet we get less information about it, by reason of its great thickness. Moreover, the great amount of overlying beds in many cases is a bar to deep exploration.

Of our Suffolk wells there are forty which go through 100 feet or more of Chalk. Of these twenty go through 200 feet or more, half of these to 300 or more, and again half of the ten to 400 or more, a very exact piece of geometric progression, or more strictly, retrogression. Although two wells pass through the great thickness of more than 800 feet of chalk, yet neither of them gives us the full thickness of the formation; for the 816 feet at Landguard Fort do not reach to the base, whilst the 843 (or 817) feet at Combs, near Stowmarket, do not begin at the top.

As in no case yet recorded has the Chalk been pierced from top to bottom in Suffolk (a defect that will be supplied during this meeting by the description of the Stutton boring), that is to say, no boring has gone from the overlying older Tertiary beds to the underlying Gault, we must now, therefore, cross the border of the county to get full information as to the thickness of the Chalk; and we have not far to go, for the well-known Harwich boring passes through the whole of the Chalk, proving a thickness of 890 feet. It is almost certain, indeed, that this should be given as a few feet more, for the 22 feet next beneath, which have been described as Gault mixed with Greensand, is probably in part the green clayey glauconitic base of the Chalk Marl. We may fairly add for this another 5 feet (as also in the case of the Combs boring), and may say that, in round numbers, the Chalk reaches a thickness of about 900 feet in the south-eastern part of Suffolk. Toward the northern border of the county it is probably more, as the deep boring at Norwich passes through nearly 1,160 feet of Chalk, and that without beginning at the top of the formation.

Of our recorded Suffolk wells only three reach the base of the Chalk, at Mildenhall, Culford and Combs; consequently we have little knowledge of the divisions of the Chalk. These divisions, indeed, are of comparatively late invention, having been evolved since the publication of many of the deep sections that have been referred to.

If the Upper Chalk at Harwich goes as far down as the flints, then we must allow it to be 690 feet thick, leaving little more than 200 for the Middle and Lower Chalk together. At Landguard Fort, from the same point of view, the Upper Chalk would certainly be 500 feet thick, and one can't say how much more.

At Combs, on the other hand, flints have been recorded as present only in the top 27 feet of the Chalk; but whilst this may have been owing in part to the boring having passed between fairly scattered nodules, and in part perhaps to insufficient care in observation, at Harwich it is possible that some flints may have been carried down in the process of boring. It should be remembered, too, that there are flints in part of the Middle Chalk, so that their presence is not an unfailing guide.

What evidence we have tends to show, however, that the Upper Chalk forms a good deal more than half, and perhaps about two-thirds, of the formation, the Middle and Lower Chalk being rather thin. This agrees with what is found in other parts where the Chalk is thick, extra thickness being chiefly due to the highest division. The glauconitic marly bed at the base seems to be well developed and to be underlain by the Gault clay; so that we have no good evidence of the occurrence of Upper Greensand. This division may be thinly represented at Mildenhall, but it is difficult to classify some of the beds passed through in the old boring there.

As far as the *Gault* is concerned little of course is known; but that little points to this formation being unusually thin, presumably only 73 feet from top to bottom at Culford, and probably not more than between 50 and 60 at and near Harwich. In the north-western part of the neighbouring county of Norfolk it is well known to be still less, the clay thinning out northward along the outcrop, until at last there is nothing but a few feet of Red Chalk between the carstone of the Lower Greensand and the Chalk. The Gault being of much greater thickness around and under other parts of the London Basin, this thinning in Norfolk and Suffolk is noteworthy. The absence of the more inconstant Upper Greensand is to be expected in most places, and calls for no remark; it may, however, be noted that geologists are coming to the conclusion that these two divisions are really parts of one formation, and one result of this geologic wedding is for the inconstancy of one partner to be greatly compensated by the constancy of the other.

The *Lower Greensand* has been found in one deep boring only, at Culford, in the western part of the county, where it is represented by $32\frac{1}{2}$ feet of somewhat exceptional beds. This slight thickness prepares us for underground thinning, and in the far east of the county the formation is presumably absent, there being no trace of it at Harwich or at Stutton.

With the Cretaceous beds we pass from the regular orderly succession of geologic formations; indeed it may be said that when we reach the base of the Gault we pass out of the region of facts into the realm of speculation.

We have come then to perhaps the most interesting problem in the geology of the Eastern Counties, to the consideration of the question, What rocks underlie the Cretaceous beds at great depths? In dealing with this I must ask your patience for frequent excursions outside our special district, and sometimes indeed far away from it.

Beyond the outcrop of the lower beds of the Cretaceous Series in Cambridgeshire and Norfolk, we find of course a powerful development of the great Jurassic Series; but the only two recorded deep borings in and near Suffolk that have pierced through the Cretaceous base, at Culford on the north-west and at Harwich on the south-east, show not a trace of anything Jurassic: they pass suddenly from Cretaceous into far older rocks. And here a paper that is to be brought before you must be anticipated, to a slight extent, by adding that the trial-boring at Stutton shows just the same thing, the Gault resting directly on a much older rock, which cannot be classed as of Secondary age.

There is no need now to discuss the literature of the old rocks underground in South-Eastern England, that has often been done. We may take the knowledge of what has been shown by the various deep borings as common property, and may use it freely, without troubling to state the source of each piece of information, and I will not therefore burden this address with references. I had indeed thought of supplementing a former account by noticing the later literature of the subject; but decided to spare you from the infliction, and myself from the trouble of inflicting; though it may be convenient to add, in the form of an Appendix, a list of the chief papers on the subject that have been published since the question was discussed at length in 1889, in an official memoir on the geology of London, and to supply some omissions in that work. Nor do I propose to make any special criticism of papers on the subject that have appeared of late years; this is hardly the occasion for controversy, which may well be put off to a more convenient season. Some general remarks, however, I shall have to make after putting the facts before you.

There are 10 deep borings reaching to old rocks in the London Basin, of which accounts have been published. We find that in 4 of these (Meux's, Streatham, Richmond, and Dover) Jurassic beds separate those rocks from the Cretaceous beds; so that there are 6 in which these last rest direct on old rocks (Ware, Cheshunt, Kentish Town, Crossness, Culford, and Harwich). Stutton of course makes a seventh. The Jurassic rocks occur only in the southern borings, either in London or still further southward, and in one case only (Dover) is there any considerable thickness of these: in the other 3 they are from $38\frac{1}{2}$ to $87\frac{1}{2}$ feet thick. As far as regards Suffolk and its borders we may therefore disregard them, except in the far west, near their outcrop, and we may pass on to consider the older rocks that have been found.

So far the occurrence, next beneath the Cretaceous or Jurassic beds, of Silurian, Devonian, and Carboniferous rocks has been proved, whilst in some cases we are still doubtful as to the age of the old rocks found. In 5 cases distinctive fossils have been found (Ware, Cheshunt, Meux's, Dover, and Harwich), but in 5 others they have not (Kentish Town, Crossness, Richmond, Streatham, and Culford), and it is in the latter group too that the character of the beds leaves their age in doubt. So far another must be added to these, as no fossil has yet been found in the old rocks at Stutton.

Of the above 10 deep borings in the London Basin (using that term in the widest sense, as including the Chalk tract that everywhere surrounds the Tertiary beds) we owe 9 to endeavours to get water from deep-seated rocks, and in addition to these 9 we have several other deep borings, which though not carried through to the base of the Secondary rocks, yet give us much information concerning those beds (at Holkham, Norwich, Combs, Winkfield, London, Loughton, Chatham, and Dover). In one case only, that of Dover, has the work been done for the purpose of exploration, but now, after a few years' interval, a second trial has been made at Stutton.

Now both of these borings were started for a much more definite object than merely to prove the depth to older rocks, or the thickness of the Cretaceous and Jurassic Series. There is one particular division of those older rocks that has a distinct fascination for others than geologists. We, happily, are content to find anything and to increase our knowledge in any direction, but naturally those who are not geologists, as well as many who are, like to find something of immediate practical value. As already shown, we owe much knowledge of the underground extension of formations to explorations for water; it has now become the turn of geologists to help those who would like to find that much less general, though nearly as needful and certainly more valuable thing, *coal*.

The first place to suggest itself to those geologists who had worked at this question, as a good site for trial, was the neighbourhood of Dover, and for various good reasons. The trial has been made, and successfully, several hundred feet of Coal Measures having been found, without reaching their base, but with several beds of workable coal.

Beyond that neighbourhood, however, geologists are not in such accord, and generally speaking, fairly good reasons can be given both for and against the selection of many tracts for trial, except in and near London, where no geologists would recommend it, from the evidence in our hands.

Let us then shortly review the evidence that we have on the underground extension of the older rocks in South-Eastern England, with a view of considering the question of the possibility of finding Coal Measures in any of the folds into which those rocks have probably, nay almost certainly, been thrown.

The area within which the borings that reach older rocks in the London Basin is enclosed is an irregular pentagon, from near Dover, on the south-east, to Richmond on the west, thence to Ware, thence to Culford on the north, thence to Harwich, and thence southward to Dover, the greatest distance between any borings being from Dover to Culford, about eighty-six miles. It is therefore over a large tract, extending of course beyond the boundaries sketched above, that we have good reason to infer that older rocks are within reasonable distance of the surface, rarely as much as 1,000 feet, and mostly a good deal less.

We must now consider some evidence outside the tract hitherto dealt with. Southward of the central and eastern parts of the London Basin we have evidence that the Lower Cretaceous beds thicken greatly, from what is seen over their broad outcrop between the North and South Downs. We know also, from the Dover and Chatham borings, that the Upper and Middle Jurassic beds come in to the south-east, whilst the Sub-Wealden Exploration, near Battle, proves that those divisions thicken greatly southward, the latter not having been bottomed at the depth of over 1,900 feet, at that trial-boring.

Westward, however, near Burford in Oxfordshire, and some miles northward of the nearest part of the London Basin, Carboniferous rocks have been found at the depth of about 1,180 feet, these being separated from the thick Jurassic beds (including therein the Liassic and Rhætic) by perhaps 420 of Trias. They consist of Coal Measures, which were pierced to the depth of about 230 feet.

In and near Northampton, north-eastward of the last site, and still further from the northern edge of the London Basin, the like occurs; but the beds found are older than the Coal Measures, and the Trias is thin, not reaching indeed to 90 feet in thickness, and being absent in one case. At one place, too, the Carboniferous beds have been pierced through, with a thickness of only 222 feet, when Old Red Sandstone was found, and in another place still older rock seems to have been found next beneath the Trias. The depth to the rocks older than the Trias, where they were reached, was 677, 738, and 790 feet, or respectively 395, 460, and 316 below sea-level. Some of these figures must be taken as somewhat approximate, though they are near enough to the truth for practical purposes.

A boring at Bletchley, to the south, reached granitic rocks at the depths of 378½ and 401 feet; but these rocks seem to be only boulders in a Jurassic clay: their occurrence, however, is suggestive of the presence of older rocks at the surface no great way off, in Middle Jurassic times.

Much further northward, at Scarle, south-west of Lincoln, the older rocks have been reached at the depth of about 1,500 feet, all but 141 of which are Trias, and they begin with the Permian (which crops out some eighteen miles westward), the Carboniferous occurring after another 400 feet, and having been pierced to 130.

We have then evidence that over a large part of South-Eastern England, reaching northward and westward of the London Basin, though the older rocks are hidden by a thick mantle of Jurassic, Cretaceous, and Tertiary beds, yet they seem to be rarely at a depth that would be called very great by the coal-miner. They are distinctly within workable depths wherever they have been reached.

There is no area of old rocks at the surface in our island, south of the Forth, in which Coal Measures are not a constituent formation. Truly, further north, in the great tract of Central and Northern Scotland there are no Carboniferous rocks; but we can hardly say that none ever occurred, at all events in the more southern parts. We know, though, that on the west and north Jurassic and Triassic beds rest on formations older than the Carboniferous.

It is not, however, to this more northern and distant tract that we should look for analogy to our underground plain of old rocks; rather should we look to more southern parts, to Wales and to Central and Northern England, where Coal Measures are of frequent occurrence. On the principle of reasoning from the known to the unknown, I cannot see why we should expect anything but a like occurrence of Coal Measures, in detached basins, in our vast underground tract of old rocks.

What, then, is the evident conclusion from what we know and from what we may reasonably infer? Surely that trials should be made to see if such hidden coal-basins can be found.

One trial has been made, and it has succeeded; the Dover boring has proved the presence of coal underground in Eastern Kent, along the line between the coal-fields of South Wales and of Bristol on the west, and those of Northern France and of Belgium on the east.

The long gap between the distant outcrops of the Coal Measures near Bristol and Calais has been lessened very slightly by the working of coal under the Triassic and Jurassic beds near the former place, but much more by our brethren across the narrow sea, the extent of the Coal Measures beneath the Jurassic and Cretaceous beds, having not only been proved by the French and the Belgians along their borders, but the coal having been largely worked. At last, we too have still further decreased the gap, by the Dover boring, a work that I trust is to be followed by other work along the same line.

But is this the only line along which we are to search? Are we to conclude that the only coal-fields under our great tract of Cretaceous beds (where these are either at the surface or covered by Tertiary beds) are in Kent, Surrey, and other counties to the west? Have we no coal-fields but those of Bristol and of South Wales? The bounds of our midland and northern coal-fields have been extended by exploration beneath the New Red Series; are we to stop here and to assume that there can be no further underground extension of the Coal Measures south-eastward? This seems hardly a wise course, and is certainly a very unenterprising one. It seems to me rather that the right thing to be done is to try to find out the real state of things, by means of borings.

There are of course objectors in this as in other matters. Some may say that it is silly to try in Suffolk, and that Essex gives a better chance of success. Others again may prefer Norfolk. And yet others may argue that there is no chance of finding Coal Measures in any of those three counties. But I must confess my inability to understand this line of reasoning; the fact is that the data we have are few and far between, and that we want more. It is really of little use to bandy words, and I do not now mean to take up the matter in detail. We cannot get at the truth except by actual work; justification by faith will not hold in this case, still less justification by unfaith.

Let us hark back a little and call to mind what has happened in the past. I remember the time when certain geologists disbelieved in the possibility of the occurrence of Coal Measures anywhere in South-Eastern England, it being argued that the formation thinned out before it could get so far eastward. Then this view was somewhat varied, and it was inferred, from certain observed facts, that even if Coal Measures did reach underground into these benighted parts, they would be without workable coal, and so practically useless.

Now for some years nothing occurred to upset the prophets of evil, that is to say, no fact came to light. There were not wanting inferences to the contrary, but it remained practically a matter of opinion. One day, however, the needful fact came, and the first boring made specially to test the question (at Dover) disproved both the above negative theories by finding Coal Measures with workable coal. Let us hope that a like result may happen in East Anglia, and that the pessimists may again be in the wrong.

We should not, however, fall into the opposite error, that of optimism. We must not expect an immediate success like that at Dover. We are here much further from any known coal-field. Advertisements of various wares sometimes tell us that 'one trial will suffice,' but it is not so in this case. We should not be content until many borings have been made, and we should not be despondent if, after sites have been selected to the best of our judgment, we begin with a set of borings that are unsuccessful in finding coal.

At the time of writing I cannot say that the Stutton boring is a success or a failure as far as coal is concerned, but I am quite ready to accept the latter without being discouraged. Whatever it is you may know during our meeting; it is certainly a success in the matter of reaching the old rocks at a depth of less than 1000 feet. We should remember that every boring is almost certain to give us some knowledge that may help in future work.

There is a further point, however, to be taken into account. A boring that may at first seem to be a failure, from striking beds older than the Coal Measures, may some day turn out otherwise. The coal-field along the borders of France and Belgium is sometimes affected by powerful and peculiar disturbances, by faults of comparatively gentle inclination (far removed from the usual more or less vertical displacements) which have thrown Coal Measures beneath older beds in large tracts. This is no mere theory, though advanced as such at first by some Continental geologists, who have had the great satisfaction of seeing their theory adopted by practical men, and proved to be true, much coal being worked below the older beds that have been pushed above the Coal Measures by the overthrust faults.

Our trial-work, of course, does not yet lead us to consider such disturbances as those alluded to. We have at first to assume a normal succession of formations, and not to carry on explorations in beds that can be proved to be older than the Coal Measures; but the time may come when it will be otherwise.

Another matter to which attention has been drawn by our foreign friends is an apparent general persistence of disturbances along certain lines, or in other words, the recurrence of disturbances in newer beds in those parts where earlier movements had affected older beds; so that, reasoning backward, where we see marked signs of disturbance for long distances in beds at or near the surface, there we may expect to find pre-existing disturbances of the older beds beneath. This, however, is a somewhat controversial question, and much remains to be done on it; but should it be proved as a general rule it may have much effect on our underground coal.

Finally, the question of the possibility of finding and of working coal in various parts of South-Eastern England is not merely of local interest; it is of national importance. The time must come when the coal-fields that we have worked for years will be more or less exhausted, and we ought certainly to look out ahead for others, so as to be ready for the lessening yield of those that have served us so well. It is on our coal that our national prosperity largely, one may say chiefly, depends, and, as far as we can see, will depend. Let us not neglect any of the bounteous gifts of nature, but let us show rather that we are ready to search for the treasures that may be hidden under our feet, and the finding of which will result in the continued welfare of our native land.

Appendix.

List of the Chief Papers on the Old Rocks Underground in South-Eastern England since 1889, when the literature of the subject was treated of in the Memoir on the Geology of London, &c.

Bertrand, Professor M. Sur le Raccordement des Bassins houillers du Nord de la France et du Sud de l'Angleterre. *Annales des Mines* and *Trans. Fed. Inst. Min. Eng.*, vol. v. (1893).

Brady, F. Dover Coal Boring. Observations on the Correlation of the Franco-Belgian, Dover and Somerset Coal Fields, 8vo. 1892. Second Issue, with Additions, 1893. Notice by **E. Lorieux** in *Annales des Mines*, 1892.

Dawkins, Professor W. B. The Discovery of Coal near Dover, *Nature*, vol. 41, pp. 418, 419; *Iron and Coal Trades Gazette*; *Contemporary Review*, vol. lvii., pp. 470–478. The Search for Coal in the South of England, *Proc. Roy. Inst.* (nine pages); *Nature*, vol. 42, pp. 319–322. The Discovery of Coal Measures near Dover, *Trans. Manchester Geol. Soc.*, vol. xx., pp. 502–517 (1890).

The Further Discovery of Coal at Dover and its Bearing on the Coal Question. *Trans. Manchester Geol. Soc.*, vol. xxi., pp. 456–474 (1892).

On the South-Eastern Coalfield at Dover, *Trans. Manchester Geol. Soc.*, vol. xxii., pp. 488–510; The Probable Range of the Coal-Measures in Southern England, *Trans. Fed. Inst. Min. Eng.*, vol. vii., 13 pages and plate (1894).

Harrison, W. J. On the Search for Coal in the South-East of England; with Special Reference to the Probability of the Existence of a Coal-field beneath Essex, 28 pages and plate. 8vo. Birmingham (1894).

Irving, Rev. Dr. A. The Question of Workable Coal Measures beneath Essex. *Herts and Essex Observer*, July 14, 1894.

Martin, E. A. On the Underground Geology of London. *Science Gossip*, no. 335, pp. 251–254; no. 337, pp. 11–15 (1892, 1893).

Rücker, Professor A. W., and **Professor T. E. Thorpe**. Magnetic Survey of the British Isles, *Phil Trans.*, vol. 181, see pp. 280 &c., and plate 14 (1891); A popular account by **Professor Rücker** under the title Underground Mountains, *Good Words*, January to March 1890.

Topley, W. Coal in Kent. *Trans. Fed. Inst. Min. Eng.*, vol. i., pp. 376–387 (1892).

Whitaker, W. Coal in the South East of England, *Journ. Soc. Arts.*, vol. xxxviii., pp. 543-557; Suggestions on Sites for Coal-search in the South-East of England, *Geol. Mag.*, dec. iii., vol. vii., pp. 514–516 (1890).

Whitaker, W., and **A. J. Jukes-Browne**. On Deep Borings at Culford and Winkfield, with Notes on those at Ware and Cheshunt. *Quart. Journ. Geol. Soc.*, vol. l., pp. 488–514 (1894).

The Eastern Counties' Coal Boring and Development Syndicate . . . Geological Reports by **T. V. Holmes, J. E. Taylor** and **W. Whitaker**, 15 pages, 8vo. Ipswich (1893). Partly reprinted in *Essex Naturalist*.

Omitted from Notice in 1889.

Drew, F. Is there Coal under London? *Science for All*, vol. v. pp. 324–328.
Firket, A. Sur l'Extension en Angleterre du Bassin houiller Franco-Belge. *Ann. Soc. Géol. Belg.*, t. x. *Bulletin*, pp. xcii–xciv (1883).
Taylor, W. On the Probability of Finding Coal in the South-East of England, pp. ii., 22, 8vo. Reigate (1886).
Topley, W. On the Correspondence between some Areas of Apparent Upheaval and the Thickening of Subjacent Beds. *Quart. Journ. Geol. Soc.*, vol. xxx. see pp. 186, 190–195 (1874). See also Memoir 'The Geology of the Weald,' pp. 241, 242, pl. vi. (1875).

The following Papers were read:—

1. *The Southern Character of the Molluscan Fauna of the Coralline Crag tested by an analysis of its characteristic and abundant species. By* F. W. Harmer, *F.G.S.*

Out of 436 species of Mollusca from the Coralline Crag, excluding varieties given in Mr. Searles Wood's monograph, nearly 90 are represented by unique specimens only, and more than 100 others are very rare. Some of these rarer forms may be only locally so, although, with few exceptions, all the species which are common in the Belgian Pliocene beds, of similar age to the Coralline Crag, are common also in that deposit. An analysis of all the shells in any horizon of the Crag in which the same value is attached to forms which are exceedingly rare, and to those which occur in countless profusion, is apt to be, to some extent, misleading. The Southern character of the fauna of the Coralline Crag, and its close resemblance to that of the Mediterranean, is much more strongly evidenced when we confine our enquiry to the more abundant shells of this deposit.

Omitting the rare species, we have 240 which may be regarded as characteristic forms. Of these 89, or about 37 per cent., are regarded by Mr. Wood as extinct, and eight others may be, for our present purpose, taken as such, as they have ceased to exist in European seas, and are only found in parts of the world more or less distant. Of the 143 species remaining, there is only one, *Buccinum* (*Buccinopsis*) *Dalei*, which is not now found living, either in the Mediterranean or the West European area, which Dr. Gwyn Jeffreys said cannot be regarded as zoologically distinct from it. This shell cannot, however, be looked on as a boreal species, as it is given by M. Dollfus as occurring in the Miocene beds of Touraine. Thirty-three of the extinct shells of the Coralline Crag are also found in the Mediterranean Pliocene, either at Monte Mario, or Biot, near Antibes. Altogether 170 species out of 396 found at Monte Mario are common to that deposit and to the Coralline Crag, a larger proportion than is the case with the Diestien beds of Belgium. The practical identity thus shown between the Molluscan fauna of the Coralline Crag, and that of the Mediterranean and West European province, and the close resemblance between both of them and some of the Italian Pliocenes, point to a more direct and open communication between the Mediterranean and the seas of Great Britain at some period subsequent to the coming into existence of the present fauna than exists at present.

The distinctly Southern character of the Mollusca of the Coralline Crag is evidenced by the comparatively small proportion of the species which range northwards into British waters, and this also comes out more strongly when we confine ourselves to its more abundant forms. While there is only one which is British, and not Southern, there are 42, or 29 per cent., of the European species which are Southern and not British. There are, however, nine shells which are characteristic Mediterranean species, and are only included in lists of the British Mollusca because of the occasional discovery of some rare specimen on our coasts. If we regard these nine species as Mediterranean, it raises the proportion of exclusively Southern forms to 36 per cent. The abundant shells are practically all Southern, and if it were possible to count shells, and not species, we should meet with some thousands of specimens of Southern Mollusca for every boreal shell we could discover. Among the extinct genera, a study of the more abundant forms also shows an equal preponderance of Southern types. Only one specimen of a truly Arctic shell, viz., *Cerithiopsis lactea*, has been met with in the Coralline Crag, but as to its correct identification Mr. Wood had considerable doubt.

Professor Prestwich, on the contrary, believes that ice action had come into existence even at the commencement of the Coralline Crag era, resting his opinion on the occurrence of a block of porphyry in the basement bed at Sutton, which, however, was neither angular nor striated, but which he thinks could only have been transported either from Scandinavia or the Ardennes by floating ice. No ice, however, reaches our shores at the present day either from Belgium or Norway, and the winter climate of Northern Europe would have to fall considerably before this could take place. At present there is a difference of not less than 10° Fahr. between the temperature, both of the sea and the atmosphere, in the British and Mediterranean areas.

Summary of the abundant and characteristic species of Mollusca occurring in the Coralline Crag.

Not known as living (37 per cent.)		89
Living in distant seas:—		
Pacific	4	
Atlantic	1	
West Indian	1	
South African	1	
North American	1	
		8
Living in the Mediterranean	133	
„ not in the Mediterranean but in the West European area	9	
		142
Not known to range to the South of British seas		1
		240

Species of European Mollusca occurring abundantly in the Coralline Crag.

Southern and not British (28 per cent.)	42
British (rare) and Southern	9
(35 per cent.)	51
British (characteristic) and Southern	91
British and not Southern	1
	143

2. *On the Derivative Shells of the Red Crag.*[1] *By* F. W. Harmer, *F.G.S.*

It has been generally held by geologists, among whom may be mentioned Mr. Searles V. Wood, Professor Prestwich, Sir Charles Lyell, and Mr. Charlesworth, that a considerable number of the Mollusca found in the Red Crag are extraneous. Mr. Wood, in the supplement to his well-known Monograph, expresses the opinion that 118 species have been derived from older deposits, principally from the Coralline Crag. Professor Prestwich thinks that only 46 species are derivative, but his list contains 13 which Mr. Wood, on the contrary, believes are Red Crag forms.

There seems much, *à priori*, to support the derivative theory. The great denudation to which the Coralline Crag has been exposed by the Red Crag sea;

[1] This and the previous paper will be published in the *Geol. Mag*

the existence over a great part of the area of the Nodule bed, which is full of derivative fossils; and the fact that many of the shells supposed to be extraneous—as, for example, *Cassidaria bicatenata, Trophon alveolatus, Cassis Saburon, Trochus Adansoni, Ringicula buccinea, Cardita chamæformis, C. orbicularis, C. scalaris, Astarte Basterotii, A. Burtinii, A. Omalii, Cyprina rustica, Gastrana laminosa, Panopæa Faujasii,* and others, are characteristic Coralline Crag species, and either southern or extinct forms, which seem out of place in a fauna as boreal as that of the Red Crag.

On the other hand, M. E. van den Broeck, of Brussels, published in 1893 lists of fossils recently discovered in the Scaldisien and Poederlien beds of Antwerp (Zones 'à *Trophon antiquum*,' and 'à *Corbula striata*'), from which it appears that the species just named, and a number of other forms supposed to be derivative in the Red Crag, lived on to a period considerably later than that of the Coralline Crag, in the eastern part of the Anglo-Belgian basin. The fauna of the Scaldisien beds closely resembles that of the Walton Crag, while the Poederlien strata seem to be more nearly related to the Sutton zone of the Red Crag. Neither of these Belgian horizons contains the purely Arctic shells, *Cardium grænlandicum, Leda lanceolata,* and *Tellina lata*, or the Arctic and boreal species, *Scalaria grænlandica, Natica grænlandica,* and *Natica clausa*, which give its peculiarly northern character to the Butley Crag, so that it would seem that they are somewhat older than that deposit. Fifty out of Mr. Wood's list of 118 species, and 23 out of 46 regarded by Professor Prestwich as extraneous, occur in these horizons of the Belgian Crag. If these shells were living during the deposition of the Sutton bed, it seems more probable that a few individuals may have survived until the period of the Butley Crag than that they are derivative at that horizon.

Some of the Red Crag shells, however, are no doubt extraneous. Five are Eocene forms, which are not found in the Coralline Crag; and there are 31 others which have been discovered only at Waldringfield or in the Nodule bed at Sutton, and neither in the Belgian nor the Coralline Crag, many of them being new to science, and most of them represented by unique specimens only.

Although a great number of fossils, such as sharks' teeth, from Eocene strata are found in the Red Crag, very few specimens of Eocene Mollusca occur in it; and it seems still less likely that shells from the Coralline Crag, which are very much more fragile, could have been preserved, except as rare exceptions, during the denudation of that deposit by the Red Crag sea.

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3. *On the Stratigraphy of the Crag, with especial reference to the Distribution of the Foraminifera.* By H. W. Burrows.

Materials collected by the author during the past eight years, and some supplied by Professor Prestwich, have been examined by Messrs. H. W. Burrows, R. Holland, and F. Chapman; and contributions by Mr. F. W. Millett have also aided in the completion of Part II. of the 'Monograph of the Foraminifera of the Crag' (Palæontographical Society). I. From the Newer Pliocene Formation—or Upper Crag—including the Norwich Crag and associated beds of Southwold, Thorpe, Bramerton, and Chillesford: there are altogether 29 species of common North Atlantic Foraminifera. II. In the Red Crag 20 species are known. III. The St. Erth beds of Cornwall, formerly noted by S. V. Wood, Jun., and R. G. Bell, and more recently by P. F. Kendall and C. Reid, are regarded as equivalent to a part of the Older Pliocene (Lower or Coralline Crag). The Foraminifera have been worked out by F. W. Millett, and amount to 163, of which 76 are met with in the Coralline Crag. IV. Professor Prestwich (1871) and Messrs. S. V. Wood, Jun., and F. W. Harmer (1872) divided the Coralline Crag into two main divisions. These were subdivided by Prestwich into eight zones ('*h*' to '*a*'), about 83 feet altogether; and by Wood and Harmer into three groups, with an estimated thickness of 60 feet.

The author then gave notes on several of the localities where exposures of these beds have been, or can still be seen; namely, beginning with the lowest zones:—1, Sutton and Ramsholt; 2, Broom Hill; 3, Sudbourne; 4, Tattingstone; 5, Sutton; 6, Gedgrave; at High House, Low Farm, and Ferry Barn; 7, Aldborough; 8, Sudbourne, north-east of the church.

The characters and thicknesses of the strata representing the several zones at these places were carefully detailed, and their most characteristic Foraminifera were enumerated and compared. V. The 'nodule-bed' at the base of the Crag, at Foxhall, was alluded to in its place. VI. The Lenham Beds of Kent were noticed as being equivalent to the Lower Crag and of Diestian age, as stated by Prestwich and confirmed by C. Reid.

Some Foraminifera found by S. V. Wood in the Coralline Crag at Sutton and elsewhere were derived from much older Tertiary beds, namely, Orbitolites, Orbiculina, Alveolina, Peneroplis, Amphistegina, Nummulites, and Orbitoides.

The most characteristic Foraminifer in the Coralline Crag is *Polymorphina frondiformis*, and it seems to be limited to England. The conclusions arrived at point to the constancy and determinability of the zones established by Prestwich. In the author's opinion the Mollusca also confirm the same zonal arrangement. Some remarks on the zonal and local distribution of several genera and species of Mollusca concluded this paper.

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4. *Note on a section at the North Cliff, Southwold. By* Horace B. Woodward, *F.G.S., of the Geological Survey of England and Wales.*

The recent damage done to the cliff at the north end of Southwold by the 'moderate gale' of last May is described below by Mr. J. Spiller. One result of the storm was the exposure of an interesting section along the lower portion of the cliff. The strata now seen comprise pebbly sands and shingle with a shell-bed, grouped by the author with the Norwich Crag; several masses of Chalky Boulder Clay, which formerly extended in one mass along the face of the cliff; a Freshwater Bed, consisting of greenish grey loam with freshwater shells and layers of gravel cemented into 'iron-pan,' overlaid by laminated peaty earth (age at present uncertain); and a Recent beach-deposit in which a human skeleton was found this year. This beach-deposit, which now forms part of the low cliff, consists of reassorted Boulder Clay, together with sand and shingle. The Freshwater Bed presents a synclinal structure, supported on either side by Boulder Clay.

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5. *On Recent Coast Erosion at Southwold and Covehithe. By* John Spiller, *F.C.S.*

Owing to the prevalence of northerly winds, culminating in a moderate gale on May 16 last, the tide rose to an unusual height all along the east coast, and attacked the soft sandy cliffs between Dunwich and Covehithe, creating a new cove at the northern extremity of Southwold and sweeping away the roadway at the back of the beach to the extent of half an acre at this particular spot. The cliffs at Easton Bavents and Covehithe likewise suffered considerably, and this loss being reported to Mr. W. Whitaker induced that gentleman to lend his maps with certain measurements noted thereon for the purpose of exact comparison. Thus provided the author walked over the ground and took fresh measurements at the several points along the route, which resulted in the determination of the amount of cliff-waste since 1882 and 1889, and this stated briefly was as follows:—

	Feet
Easton Bavents, loss in six years	20
Easton High Cliff, loss in thirteen years	22
Covehithe Cliff, loss in six years	84

The accuracy of these observations was checked by Mr. Horace B. Woodward, and other indications observed conjointly proved that the general loss at Covehithe amounted to about 50 yards since the present Ordnance map was constructed. The lines of high and low water mark had manifestly altered, so that a fresh survey was necessary. Further details were given as to the nature of the rock sections laid bare and the transportation of the shingle; and the main facts were illustrated by photographs and a water-colour sketch of the new inlet formed at Southwold.

[The author's communication was printed in full in the Supplement to the 'East Anglian Daily Times' of September 13, 1895.]

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6. *Observations on East Anglian Boulder Clay.* *By* Rev. E. Hill, *M.A.*, *F.G.S.*

Some personal observations are described, and inferences from them suggested.

The present effect of frost on clay shows that the grinding actions of land-ice need not be invoked.

The comparative distributions of Kimmeridge clay and chalk, and also the intimate mixture of chalk-fragments with clay-matrix, are opposed to land-ice theories.

A partially scratched fragment from the heart of the clay suggests flotation.

The contour line of 300 feet includes little Chalk but much Boulder Clay, which is said to reach altitudes in the Midlands higher than any Chalk. This points to alteration in relative as well as absolute levels.

A resemblance to some artificial clays suggests that the Boulder Clay may have been deposited rather rapidly. If so, the absence of life is no difficulty; neither is the alleged absence of stratification.

These inferences would all agree with deposition in water, and with a tilt of the earth-surface.

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7. *Indications of Ice-raft Action through Glacial Times.* *By* Rev. E. Hill, *M.A.*, *F.G.S.*

Over post-Glacial gravels lie sheets of Boulder Clay. In the Boulder Clay scratched stones, contorted sands at Sudbury, gravel and chalk at Claydon, the Roslyn Hill chalk at Ely, are best explained by transportation and dropping. In mid-Glacial sands, between Gorleston and Lowestoft, portions of Boulder Clay occur in the midst of the sands, as if dropped by ice-rafts. A majority of writers on the Cromer cliffs attribute the chalk masses in the Contorted Drift to ice-rafts.

Thus through Glacial times are indications of ice-raft action.

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8. *On Traces of an Ancient Watercourse.* *By* Rev. E. Hill, *M.A.*, *F.G.S.*

A peculiar gravel occurring along a line of seven miles indicates an ancient brook. Though its hollow is in Boulder Clay, yet patches of like clay overlie the gravel, and probably have been carried down on to it in a frozen state. The nature of the gravel agrees with its having been formed on land little elevated.

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9. *Further Notes on the Arctic and Palæolithic Deposits at Hoxne.* *By* Clement Reid, *F.L.S.*, *F.G.S.*, *and* H. N. Ridley, *M.A.*, *F.L.S.*

The exact relations of the deposit with Arctic plants discovered in 1888 (see British Association Report, p. 674) to the Palæolithic deposits and to the Boulder Clay in the same pit being still uncertain, the authors returned last spring, intending to pump out the water and examine the beds in place. This they were unable to do owing to the water being required for the brickyard; but by means of borings and an examination of the deposits above the water level they ascertained that the succession was probably as follows:

		Feet
Gravelly surface soil	about	2
Brickearth: towards the base *Valvata piscinalis*, cyprids, bones of ox, horse, elephant (?), and Palæolithic implements	„	12
Sandy gravel, sometimes carbonaceous, with flint flakes	„	1
Peaty clay, with leaves of Arctic plants (?) . . .	„	4
Lignite, with wood of yew, oak (?), white birch, and seeds of cornel, &c.	„	1
Green calcareous clay, with fish, *Valvata piscinalis*, *Bythinia tentaculata*, cyprids, *Ranunculus repens*, *Carex*	„	4
Boulder clay.		

The authors suggest the appointment of a committee to continue this work, as Hoxne is apparently the best locality in the Eastern Counties for ascertaining the relation of Palæolithic man to the Glacial epoch. The seeming occurrence of a temperate flora between the morainic deposits and the clays with Arctic plants should also be investigated and decided beyond question.

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10. *Some Suffolk Well-sections. By* W. WHITAKER, *F.R.S.*
Ordered to be printed *in extenso.*—See Reports, p. 436.

FRIDAY, SEPTEMBER 13.

The following Papers and Reports were read:—

1. *On Pitch Glaciers or Poissiers. By* Professor W. J. SOLLAS, *D.Sc., F.R.S.*

Pitch and the ice of glaciers strikingly resemble each other in behaving as solids and liquids, according to their manner of treatment. On the sudden application of force they break like brittle material, but yield like fluids when subjected to gradual pull or pressure. Hence it is possible to employ pitch in the construction of working models of glaciers in order to obtain an insight into those internal movements of actual glaciers which are beyond the reach of direct observation. The study of glacial deposits has shown that many erratic boulders were transported during the Glacial period upwards from lower to higher levels, and left stranded on the flanks of mountains some hundreds of feet above their source. This standing difficulty in the way of physical theories of glacier movement has been explained by the study of pitch models, which show that the lower layers of material on approaching an obstacle are carried upwards in an ascending current. The inference, which is confirmed by other kinds of observation, is that similar movements take place in actual glaciers. Further, a glacier sometimes overrides its terminal moraine without disturbing it; and in one experiment this was exemplified, for pitch flowed for several months over a ridge of loose material without removing a particle of it. A remark made by Professor Fitzgerald, to the effect that viscosity seemed merely to retard, and not to alter, the nature of the movement in the cases described led the author to experiment with less viscous material, such as Canada balsam and glycerine, and with concordant results. A trough containing Canada balsam flowing upwards over an obstacle under its own head of pressure was shown by the lantern projected on the screen.

A raised model of Ireland has been constructed, and the directions of ice-movement, as determined by the Rev. Maxwell Close, indicated upon it by arrows. On allowing water streaked with colouring matter to flow over it from two areas, supposed to represent the great gathering grounds of snow of the Glacial period, the water had taken paths, as shown by coloured streaks, corresponding to those taken by the ice, as shown by the arrows.

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2. *Notes on the Cromer Excursion.* *By* Clement Reid, *F.G.S.*

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3 *On the Tertiary Lacustrine Formations of North America.* *By* W. B. Scott.

The early French explorers in the western parts of North America discovered certain large areas of extraordinarily broken and difficult country which they called 'mauvaises terres à traverser'—a term which has been translated and shortened into the modern phrase 'bad lands.' Geological examination soon showed that these areas were covered with fresh-water deposits of Tertiary age, and that they represented a series of great lakes in which were entombed a vast number of representatives of the vertebrate faunas which successively occupied the country.

I. (1) The most ancient of these formations is the Puerco, which overlies with apparent conformity the Cretaceous. This rather small lake occupies parts of Southern Colorado and North-western New Mexico. (2) The Wasatch succeeds after an interval and was much larger: it extends from New Mexico into Northern Wyoming. At least two contemporaneous lakes represent this horizon, and at the south its strata lie upon the Puerco. (3) The Bridger is indicated by a much smaller series of lakes, in Wyoming, Utah, and Colorado, which seem to have been successive rather than contemporaneous, and has been divided into three stages: (*a*) Wind River, (*b*) Bridger, (*c*) Washakie. The Wasatch beds pass under the Bridger at very many points. (4) Extensive orographic movements followed the Bridger stage and led to the formation of a new lake basin in Northern Utah, overlying the Bridger—the Uinta. Osborn has shown that two distinctly marked horizons occur within the limits of the Uinta. (5) The Uinta was the last of the great bodies of fresh water in the region to the west of the main chain of the Rocky Mountains. The movements now affected the Great Plains region, and an enormous lake was developed which extended along the *eastern* front of the mountains from Nebraska into North Dakota, together with a second basin in Canada. This is the White River formation, which is plainly subdivisible into three horizons—the Titanotherium, Oreodon, and Protoceras beds. (6) This was followed by the John Day, which is mostly confined to Oregon, but a second very small basin occurs also in Central Montana. (7) A considerable hiatus separates the John Day from the overlying Loup Fork, which is by far the most extensive of all the Tertiary lakes, and covers nearly all the Plains region, from South Dakota far into Mexico. It is not yet certain whether this was one vast body of water or a connected series of lakes. Independent basins occur in Montana, Nevada, and Oregon. In these the Loup Fork overlies the John Day unconformably, as farther east it overlies the White River. The Loup Fork falls naturally into three horizons, separated both by their faunas and more or less marked unconformities: (*a*) Deep River, only in Montana; (*b*) Nebraska, the principal area of the Plains region; (*c*) Palo Duro, known in Kansas, but principally developed in Texas. (8) In the Indian territory and Texas, in places overlying the Palo Duro, occurs the Blanco, the boundaries of which have not been traced as yet. (9) Occupying the surface of most of the Great Plains region are the uncompacted and obscurely stratified *Equus* beds, which rest unconformably upon all other formations of the region, from the Cretaceous to the Pliocene.

II. The Lacustrine beds have for the most part retained their horizontal position, only rarely being tilted. They are composed of felspathic muds, clays, sands, and conglomerates, generally cemented by some calcareous compound, and their hardness is, speaking broadly, proportionate to their antiquity. The removal of the soluble cement by rain-water causes the rock to crumble, and the bad lands are examples of atmospheric erosion on a very grand scale. This erosion is extremely slow, the soil shedding the rain almost completely, but land-slips and snow avalanches in the spring frequently expose fresh surfaces of rock. The John Day beds are largely composed of the glassy particles of volcanic ash and the whole is overlaid by late basaltic flows.

In the lake basins the old shore lines and deltas may frequently be traced, and their fossil contents sometimes afford interesting hints as to the habitat of the land animals.

Climatic changes are registered in the alteration of the floras, as in the gradual disappearance of the palms from the central latitudes and in the diminution in the abundance and variety of the reptiles. For example, large crocodiles are exceedingly common in all the Eocene formations, including the Uinta, but in the succeeding White River only a few dwarf forms have been found.

III. The correlation of formations in different continents is a difficult matter, but least so, perhaps, in the case of lacustrine beds in *connected* areas. The Old and New Worlds were certainly so connected during much, if not all, of Tertiary time, and there is always a certain proportion of land mammals common to the two continents. The natural and sharply marked lines of division are, however, not the same, and were the American formations arranged without reference to those of any other continent, a system very different from the European would result. Thus the Puerco would form one group; the Wasatch a second; the Bridger, White River, and John Day a third; the Loup Fork and Blanco a fourth; and the Equus beds a fifth.

The European system is, however, the standard, and must be employed, and even in this way some very close correspondences may be noted. Thus, the Puerco is somewhat older than the Cernaysian, while the Wasatch is the exact equivalent of the Suessonian. The Bridger is Middle Eocene (Parisian or Lutetian), and the Uinta in a general way corresponds to the Paris gypsum. The White River is Oligocene (Ronzon), and much misunderstanding has come from calling it Miocene. The John Day may be placed in the Lower Miocene, though it is somewhat older than the beds at St. Gérand-le-Puy, and follows the White River epoch with hardly a break.

None of the American lacustrines is referable to the Middle Miocene. The Loup Fork is Upper Miocene, the Deep River division corresponding almost exactly to the beds of Sausan and Steinheim, while the Palo Duro division is perhaps already basal Pliocene. The fauna of the Blanco series is not yet sufficiently well known for exact correlation, though there can be no doubt that it is Pliocene.

The Equus beds are distinctly Pleistocene, though it still remains to trace their relations to the Drift and to determine whether they are pre-Glacial or Glacial.

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4. *The Glacial Age in Tropical America.* *By* R. BLAKE WHITE.

The deposits described by the author cover almost the whole of the Republic of Colombia, extending from 12° N. lat. nearly to the Equator, and from the summits and plateaux of the Andes at 10,000 and 12,000 feet down to the plains, valleys, and littorals of the Atlantic and Pacific Oceans. The Glacial age corresponded, in his opinion, with that of greatest volcanic activity. He speaks of moraines from 2,000 to 3,000 feet thick, accumulation of boulders, erratics of enormous size, and a peculiar loess on the high lands, the last containing bipyramidal crystals of quartz supposed to have been formed *in situ.* Great denudation followed the melting of the ice, and the auriferous deposits of the country belong to this or to the Glacial age. The author considers that a decrease in temperature enough to bring the snow line from 2,000 to 3,000 feet lower than it is at present would account for the phenomena which he describes. This might be brought about by a diminution of the amount of carbonic acid in the atmosphere, producing rarefaction. He concludes by urging geologists to investigate a country which offers such a promising field, and does not present to the traveller any difficulties of importance.

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5. *On pre-Glacial Valleys in Northamptonshire.* *By* BEEBY THOMPSON, *F.C.S., F.G.S.*

The paper refers to the pretty general belief that the larger physiographical features of this country were developed before the Glacial period, and that many of the present river valleys are of pre-Glacial age; and remarks that, if so, they were more or less completely choked with boulder clay during the Glacial period.

Where a valley got completely filled up it would, perhaps, in many cases be easier for the ordinary drainage to cut out a new valley than to remove the infilling of an old one, where the initiative for a new valley had been given by superficial streams due to melting ice. So at the close of the Glacial period, although the main drainage of a district must take approximately the same direction that it did before it, the tributary streams would seldom accurately follow their old lines on having, as it were, a fresh start under somewhat different circumstances. Compromises would, no doubt, frequently result.

Bearing these matters in mind, we should be prepared to find—

1. New valleys without drift, and filled-up old ones near at hand.
2. Valleys with one side drift and the other the normal rocks of the district.
3. Valleys still containing much drift, with the streams running over or through it.
4. Valleys in which only the coarser material of the drift is left in the form of river gravel.

Illustrations of each of the four cases enumerated are given, all from Northamptonshire.

The author suggests that his explanation of some isolated patches of boulder clay near to Northampton may prove to be of more general application than previously suspected.

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6. *Notes on some Tarns near Snowdon.* *By* W. W. WATTS, *M.A., F.G.S.*

During a recent visit to Snowdon, the writer has taken the opportunity of examining a few of the tarns in its immediate vicinity. These include the two small lakes in Cwm Glas, Glaslyn, and Llyn Llydaw.

In the hollow of Cwm Glas there are two tiny tarns named Ffynnon Frech and Ffynnon Felen; both lakes drain over a barrier of rock, but in a rainy season the upper one appears to find a second outlet over the long, low col to the East, so that, in this state, it has the two outlets depicted in the 6-inch map. There can be little doubt that this upper lake is a portion of a bending valley dammed at both ends by scree- and stream-débris, and thus compelled to find an escape over the rocky side. The lower lake is certainly confined in a rock basin, as rock occurs at its actual outlet and at every point where any former outlet might have been possible. The lake is, however, so shallow that its occurrence in a basin of rock is perhaps of little consequence.

The neighbouring hollow of Cwm Dyli, as is well known, contains three lakes, the highest being Glaslyn, the next Llyn Llydaw, and the lowest Llyn Teyrn. Glaslyn is bounded on all sides by live rock except at and near its outlet. This exit is over moraine, which, however, is evidently not very deep, for rock makes its appearance just below, and in such a way as to almost compel belief in a complete rock bar. Beside the present course of the effluent stream is a parallel strip of moraine running down towards Llyn Llydaw, but living rock soon makes its appearance in this in such a way as to show that if there is any old channel in this direction it must be exceedingly narrow and tortuous. Thus, if this lake is not contained in a true rock basin, it must be very shallow or else must have found exit by a gorge quite as narrow as those found at the end of some of the Swiss glaciers.

Immense quantities of moraine material occur on the south-east side of Llyn Llydaw, but a careful examination of the map and the ground shows that only two possible outlets exist—that now used for this purpose, and a second which is occupied by bog resting on moraine, and gives rise to a small stream which is joined lower down by the outlet of Llyn Teyrn. The moraine is, however, only a thin skin on the surface of rock. The present outlet shows live rock forty or fifty feet below the level of the lake, and the second possible exit at a rather less distance below the same level. If the moraine were stripped off, there is little doubt that this lake, like Glaslyn, would show a basin of rock which would hold water, unless it is very much shallower than is generally supposed to be the case.

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7. *Interim Report on the High-level Shell-bearing Deposits of Clava, &c.*

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8. *Interim Report on the Calf Hole Cave Exploration.*

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9. *Report on the High-level Flint Drift of the Chalk.*
See Reports, p. 349.

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10. *Report on the Rate of Erosion of Sea Coasts.*
See Reports, p. 352.

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11. *Final Report on Underground Waters.*—See Reports, p. 393.

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12. *On Modern Glacial Striæ.*
By PERCY F. KENDALL, *F.G.S.*, *and* J. LOMAS, *A.R.C.Sc.*

The authors have spent several weeks during the present summer among the glaciers of the Nicolaithal and the Val Tournanche, and have paid especial attention to the form and distribution of glacial striæ. The present communication deals with four principal sets of phenomena.

1. *The Crossing of Two or more Sets of Striæ.*—In the discussion of the glacial geology of Britain and other countries writers have ascribed the formation of two superposed sets of striæ on one surface either to the action of floating ice or to a different period of glaciation. The authors have found that the phenomenon is of quite general occurrence, especially on the steeply inclined 'weather'-sides of *roches moutonnées.* They have observed an angular divergence of 89°.

2. *The Forms of Striæ as a Means of determining the Direction of Ice-movement.*—It is often impossible to decide *à priori* whether a particular scratch or set of scratches was produced by ice moving, say, from south to north, or from north to south. The late Professor Carvill Lewis thought that striæ having a broad and a narrow end would furnish reliable criteria, but the authors, after careful examination of a large number, are unable to regard such characters as possessing the required degree of constancy.

3. *The Phenomena known to American Glacialists as 'Semilunar Markings,' 'Pluck-marks,' and 'Chattered Striæ.'*—The authors found many examples of these features of glacial abrasion upon *roches moutonnées*. The 'pluck-marks' were found to be shallowest at their 'downstream' ends. 'Chattered striæ,' *i.e.*, ragged striæ presenting somewhat the appearance of a succession of bruises, were very common. They were probably produced by boulders that were only partially embedded in the ice, and were thus dragged along with a jerking motion.

It is satisfactory that these minor details of the glacial phenomena of the United States can be paralleled in the Alps.

4. *The Occurrence of 'Screwed' or Curved Striæ.*—Authors have ascribed the formation of sharply curved or screwed striæ to the swinging of floating ice when partly aground. The present writers have observed and recorded by heel-ball 'rubbings' and by photography many examples occurring on the *roches moutonnées* of the Gorner Glacier.

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13. *Notes on the Ancient Physiography of South Essex.* *By* T. V. Holmes.

The author refers to his paper, read before the Geological Society last year, entitled, '*Further Notes on some Sections on the New Railway from Romford to Upminster, and on the Relations of the Thames Valley Beds to the Boulder Clay.*' In that paper he mentioned the discovery, in a railway cutting at Romford, of part of an ancient silted-up stream course of considerable size, covered by gravel belonging to the highest, and presumably oldest, terrace of the Thames Valley system. In this communication he considers more fully the evidence bearing upon his view that the course taken by this ancient stream was between the high ground of Warley, Billericay, and Maldon, and that of Laindon, Rayleigh, and Althorne into the Blackwater, the basins of the Mardyke and Crouch having originated at a much later period. He also notes evidence tending to confirm Mr. Whitaker's view that the gravel and loam at and near Canewdon, Southminster, and Bradwell were deposited on the western flank of the old Thames Valley when there was a considerable breadth of land east of those places, which has been since removed by marine denudation.

SATURDAY, SEPTEMBER 14.

The following Papers and Report were read:—

1. *Restorations of some European Dinosaurs, with Suggestions as to their Place among the* Reptilia. *By* Professor O. C. Marsh.

For several years I have been engaged in investigating the Dinosaurs of North America, where these extinct reptiles were very abundant during the whole of Mesozoic time. The results of my study have been published from time to time, and I have already had the honour of presenting some of these to the British Association. In carrying out this investigation so as to include the whole group of Dinosaurs, wherever found, and bringing all under one system of classification, it has been necessary for me to study the remains discovered in Europe, and I have made several visits to this country for that purpose.

In comparing the forms known from the two continents, certain important differences as well as some marked resemblances between the two have been observed and placed on record. In concluding my investigations of the North

American forms, I have fortunately been able to make restorations of the skeletons of quite a number of very complete type specimens, and this has proved a most instructive means of comparing those from different horizons, and of different groups, among the known *Dinosauria* of America.

The success of this plan rendered it very desirable to extend it, if possible, to the best-known forms of European Dinosaurs. This I have been enabled to do in a few instances, and the main object of the present paper is to lay these latest results before you.

Restorations of European Dinosaurs.

The restorations of Dinosaurs which I have to present are four in number, and represent some of the best-known European forms, types of the genera *Compsognathus*, *Scelidosaurus*, *Hypsilophodon*, and *Iguanodon*. These outline restorations have been prepared by me mainly for comparison with the corresponding American forms, but in part to insure, so far as the present opportunity will allow, a more comprehensive review of the whole group. The specimens restored are all of great interest in themselves, and of special importance when compared with their nearest American allies.

Compsognathus.

The first restoration, that of *Compsognathus longipes*, Wagner, 1861, shown natural size in the diagram, is believed to represent fairly well the general form and natural position, when alive, of this diminutive carnivorous Dinosaur, that lived during the Jurassic period. The basis for this restoration is (1) a careful study of the type specimen itself, made by me in Munich in 1881; (2) an accurate cast of this specimen, sent to me by Prof. von Zittel; and (3) a careful drawing of the original made by Krapf in 1887. The original description and figure of Wagner (Bavarian Academy of Sciences, 1861) and those of later authors have also been used for some of the details. No restoration of the skeleton of this unique Dinosaur has hitherto been attempted.[1]

Compsognathus has been studied by so many anatomists of repute since its discovery that any attempt to restore the skeleton to a natural position will be scrutinised from various points of view. My interest in this unique specimen led me long ago to examine it with care, and I have since made a minute study of it, as related elsewhere, not merely to ascertain all I could about its anatomy, but also to learn, if possible, what its relations were to another diminutive form, *Hallopus*, from a lower horizon in America, which has been asserted to be a near ally. Both are carnivorous Dinosaurs, probably, but certainly on quite different lines of descent.

The only previous attempt to restore this remarkable Dinosaur was by Huxley, when in America in 1876. He made a rapid sketch from the Wagner figure, and I had this enlarged for his New York lecture. This sketch, reproduced on the diagram exhibited, represents the animal sitting down, a position which such Dinosaurs occasionally assumed, as shown by the footprints in the Connecticut Valley, which Huxley examined in place at several localities with great interest.

The great majority of Dinosaurian footprints preserved were evidently made during ordinary locomotion, although some series show evidence of more rapid movement. All those referred to carnivorous Dinosaurs are bipedal, and this is true of the footprints of many herbivorous forms.

In the present restoration of *Compsognathus*, I have tried to represent the animal as walking, in a characteristic lifelike position.

[1] The remains of the embryo within the skeleton of *Compsognathus*, first detected by me in 1881, while examining the type specimen, are not represented in the present restoration. This unique fossil affords the only known evidence that Dinosaurs were viviparous.

Scelidosaurus.

The second of these restorations is that of *Scelidosaurus Harrisonii*, of Owen, shown natural size in the diagram. This reptile was an herbivorous Dinosaur of moderate size, related to *Stegosaurus*, and was its predecessor from a lower geological horizon in England. This restoration is essentially based upon the original description and figures of Owen (Palæontographical Society, 1861). These have been supplemented by my own notes and sketches, made during examinations of the type specimen, now in the British Museum.

Scelidosaurus is a near relative, as it were, of one of our American forms, *Stegosaurus*, now represented by so many specimens that we know the skull, skeleton, and dermal armour, with much certainty. The English form known as *Omosaurus* is still more nearly allied to *Stegosaurus*, perhaps identical.

A restoration of the skeleton of *Scelidosaurus*, by Dr. Henry Woodward, will be found in the British Museum Guide to Geology and Palæontology, 1890, p. 19. The missing parts are restored from *Iguanodon*, and the animal is represented as bipedal, as in that genus.

In the present outline restoration of *Scelidosaurus*, I have endeavoured merely to place on record my idea of the form and position of the skeleton, when the animal was alive, based on the remains I have myself examined. In case of doubt, as, for example, in regard to the front of the skull, which is wanting in the type specimen, I have used a dotted outline, based on the nearest allied form. Of the dermal armour, only the row of plates best known is indicated. The position chosen in this figure is one that would be assumed by the animal in walking on all four feet, and this I believe to have been its natural mode of progression.

Hypsilophodon.

The third of these restorations, that of *Hypsilophodon Foxii*, Huxley, 1870, given in outline, natural size, in the diagram, has been made with much care, partly from the type specimen, and in part from other material mostly now in the British Museum. The figures and description by the late Mr. Hulke[1] were of special value, although my own conclusions as to the natural position of the animal when alive do not coincide with those of my honoured friend, who did so much to make this genus of Dinosaurs, and others, known to science. The restoration by Mr. Hulke is shown in another diagram.

In the case of *Hypsilophodon*, a number of specimens are available instead of only one. This makes the problem of restoration in itself a simpler matter than in *Scelidosaurus*. Moreover, we have in America a closely allied form, *Laosaurus*, of which several species are known. A study of the genus *Laosaurus*, and the restoration of one species given on the diagram exhibited will clear up several points long in doubt.

Huxley and Hulke both shed much light on this interesting genus, *Hypsilophodon*, indeed, on many of the *Dinosauria*. The mystery of the Dinosaurian pelvis, which baffled Cuvier, Mantell, and Owen, was mainly solved by them, the ilium and ischium by Huxley, and the pubis by Hulke. The more perfect American specimens have demonstrated the correctness of nearly all their conclusions.

Iguanodon.

The fourth restoration exhibited, that of *Iguanodon Bernissartensis*, Boulenger, 1881, one-fifth natural size, has been made in outline for comparison with American forms. It is based mainly on photographs of the well-known Belgian specimens, the originals of which I have studied with considerable care during several visits to Brussels. The descriptions and figures of Dollo[2] have also been used in the preparation of this restoration. A few changes only have been introduced, based mainly upon a study of the original specimens.

[1] *Philosophical Transactions*, 1882.
[2] *Bulletin Royal Museum of Belgium*, 1882–88.

Beside the four genera here represented, no other European Dinosaurs at present known are sufficiently well preserved to admit of accurate restorations of the skeleton. This is true, moreover, of the Dinosaurian remains from other parts of the world outside of North America.

To present a comprehensive view of the Dinosaurs, so far as now known, I have prepared the plate exhibited, which gives restorations of the twelve best-known types, as I have thus far been able to reconstruct them. Of these twelve forms, eight are from America: *Anchisaurus*, a small carnivorous type from the Trias; *Brontosaurus, Camptosaurus, Laosaurus*, and *Stegosaurus*, all herbivorous, and the carnivorous *Ceratosaurus*, from the Jurassic; with *Claosaurus* and *Triceratops*, herbivores from the Cretaceous. These American forms, with the four from Europe already shown to you, complete the series represented on the chart exhibited. They form an instructive group of the remarkable reptiles known as *Dinosauria*.

The geological positions of *Compsognathus* and of *Scelidosaurus* are fully determined, but that of *Hypsilophodon* and *Iguanodon* is not so clear. The latter are found in the so-called Wealden, but just what the Wealden is I have not been able to determine from the authorities I have consulted. The Cretaceous age of these deposits appears to be taken for granted here, but the evidence as it now stands seems to me to point rather to the upper Jurassic as their true position. If I should find the vertebrate fossils now known from your Wealden in the Rocky Mountains, where I have collected many corresponding forms, I should certainly call them Jurassic, and have good reason for so doing. Moreover, after visiting typical Wealden localities here and on the Continent, I can still see no reason for doing otherwise so far as the vertebrate fossils are concerned, and in such freshwater deposits their evidence should be conclusive. I have already called attention to this question of the age of the Wealden, and do so again, as I believe it worthy of a careful reconsideration by English geologists.

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2. *Report on the Investigation of the Locality where the Cetiosaurus Remains in the Oxford Museum were found.*—See Reports, p. 403.

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3. *Preliminary Notice of an Exposure of Rhætic Beds, near East Leake, Nottinghamshire. By* MONTAGU BROWNE, *F.G.S., F.Z.S.* (*Fourth Contribution to Rhætic Geology.*)

On the confines of Leicestershire and Nottinghamshire, near East Leake in the latter county, the extension of the Manchester, Sheffield, and Lincolnshire Railway has lately exposed an interesting section by the tunnel, which cuts through the White Hills, under the high road, and is bounded on the west by the coppice called the 'Devil's Garden,'[1] which is near the end of a westerly extension or promontory of the Liassic with Rhætic beds.

The ordinary appearance of Midland exposures is here exhibited, and many of the beds are homotaxial, both by lithology and contained fossils, with those of exposures so remote as Wigston in Leicestershire, Westbury-on-Severn, Pylle Hill at Bristol, and Watchet in Somersetshire. As in these exposures, there is no actual or massive bone-bed as at Aust, &c., although, most curiously, one piece—and one only, identical with the Aust breccia—was picked up at the 'tip.' The usual minerals are present in the shales and stone, viz., selenite, iron pyrites, oxides and peroxides of iron, and galena sparingly. The fossils are interesting, not only as supplementing those previously alluded to by the writer in former contributions,[2] but as exhibiting some rare forms not previously recorded for Britain, as given in the following list:—

[1] This ancient and singular appellation is suggested by the writer as probably due to the exposure of the black shales here in digging, the surroundings being a wide area of Keuper red marls.

[2] *British Association Reports*, 1891–2–4.

SECTION OF TRIASSIC BEDS, EAST LEAKE TUNNEL, NOTTS.

		Ft.	in.	
Upper Rhætic.	K—Marls, grey, sandy, weathering light grey, and breaking with a somewhat conchoidal fracture, not unlike the 'tea-green' marls of the Upper Keuper . . Variable, 7 ft. to	12	0	Apparently unfossiliferous.
	J—Limestone, hard, white, septariform, calciferous, and breaking with a cuboidal fracture . . 3 in. to	0	6	
Lower Rhætic or *Avicula contorta* zone.	I—Shale, laminated, dark grey, nearly black	12	0	
	H—Shales, rusty black, not so thinly laminated as E	2	0	Upper portion crowded with *Isodonta Ewaldi*, *Myaphoria inflata*, &c.
	G—Sandstone, pyritous, similar in character to C, and fairly persistent ½ in. to	0	1	
	F—Shales, black, with several rusty bands .	1	3	
	E—Shale, dark, standing out as a hard band, and cutting out into large squares, but weathering into the thinnest paper shales . . Variable, about	1	0	Nearly unfossiliferous.
	D—Shale, thickly laminated	5	0	
	C—Sandstone, pyritous, with a little galena . . . . . 1 in. to	0	2	
	B—Shale, black	1	2	Fish scales, &c.
Upper Keuper.	A—Marls, indurated, grey-green ('tea-green' marls), becoming harder and greyer in parts	16	6	Nearly unfossiliferous.
		51	8	

The fossils are

PLANTÆ.

Pterophyllum (*? brevipenne*), Heer.

INVERTEBRATA.

Pecten valoniensis, Defrance.
Avicula contorta, Portlock.
Myaphoria inflata, Emmerich.
Cardium philippianum, Dunker.
Isodonta ewaldi, Bornemann.
Anatina præcursor, Quenstedt.
Actæonina (*? valleti*), Stoppani.
Several others not yet determined.

VERTEBRATA.

Hybodus minor, Agassiz—teeth.
Acrodus minimus, Agassiz—teeth.
Nemacanthus monilifer, Agassiz—spines.
Gyrolepis albertii, Agassiz—scales.
Labyrinthodon, sp.—parts of jaws and teeth, and some other portions not yet determined.
? Dinosaurian limb-bones.
'*Rysosteus oweni*,' Woodward and Sherborne.
Several other specimens not yet determined.

Lower Lias.

To the south of the tunnel, several minor and one major fault have let down the Rhætic and Lower Lias—which is here exposed as part of the great Hoton and Buckminster fault—with an inverted downthrow. The beds of the *Planorbis* zone, as usually exhibited in Leicestershire, are here present, resting on disturbed Upper Rhætic grey, sandy marls. with the usual septariform nodules.

The writer defers, however, the full consideration of this portion until certain sections, now in progress, are united to give the proper sequence.

MONDAY, SEPTEMBER 16.

The following Papers and Reports were read :—

1. *Probable Extension of the Seas during Upper Tertiary Times in Western Europe. By* G. F. Dollfus.

Taking into consideration the position and nature of all the outliers of Upper Tertiary age, the author is led to the following conclusions as to the extension of the Neogenic seas in Western Europe. During Miocene times England was united to France, and we have proof of the existence of two seas in the western part of Europe ; one on the east extended over part of Belgium (Bolderian system), Holland, and north of Germany—probably this sea was not very far off the eastern coast of England ; the other sea, the Western, or old Atlantic Sea, was off Ireland, penetrating in various gulfs into France, as in some part of Côtentin, Brittany, in the Loire valley, in the gulf of the Gironde, but there was no way of communication with the Mediterranean basin crossing France. In North Spain there are no Miocene deposits, in Portugal Miocene beds are purely littoral.

The communication with the Mediterranean Sea was certainly by the valley of the Guadalquivir. The Gibraltar Strait had not exactly its present place. The fauna of these Miocene coasts was warm and very similar to the existing fauna of Senegal and Guinea.

We can divide Pliocene time into three periods, but the situations of the seas were not very different. England was always in direct continental communication with France, the English Channel was not open at all. All the Pliocene deposits of Belgium, North France, or England, even the Lenham beds, are on the side of the North-Eastern Sea ; we find all these patches on the northern side of the great anticlinal line of the Artois, Boulonnais, and Weald. The fauna is different from the Miocene, and colder—it even turns more and more cold during the progress of Pliocene time. On the western or Atlantic side we have little gulfs leading the sea into the land, but not so frequently and not so far as during Miocene times. The Cornwall deposits, Côtentin beds, and the Brittany patches are very limited ; the basin of the Gironde contains no trace of Pliocene beds, and we have no trace of recent marine beds at the foot of the Pyrenees. In the north of Spain there is also no trace of Pliocene beds. The continent seems to have been higher, and the Atlantic tolerably distant. All the Portuguese sands recently discovered are littoral, and only on the Algarve coast and south of Spain do we find proof of the probable communication with the Mediterranean. The Gibraltar Strait was not always in the same place during Pliocene time ; in the beginning probably the Guadalquivir valley to Murcia continued to be the strait, but later the rock of Gibraltar was separated from Africa and a new road was open ; this way was certainly deeper than the former one, and as deep as the existing strait. By this depression the cold fauna of the depths of the Atlantic penetrated into the Mediterranean Sea as far as Sicily and Italy with *Cyprina Islandica*.

The geology of Morocco is unknown, but we have plenty of information on Algeria. We have there great Miocene deposits raised along the Atlas Chain up to a great altitude, and a little lower a good and very long band of Pliocene beds of marine and continental origin. Quaternary deposits, similarly continental and littoral, occur lying along the actual coast, pointing out the south side of the Mediterranean connection.

In a few words, the English Channel has been opened very recently, and no sea occupied its place before. No sea has crossed France or central Spain, and we are obliged to seek for an outlet for the Eastern Sea during Miocene time by way of Germany, Galicia, and South Russia, or by the north of Scotland.

During the existence of the Pliocene seas there was no other communication for the Crag seas than the northern one, for the western, the south, and eastern sides were undoubtedly shut in by land.

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2. *On the Present State of our Knowledge of the Upper Tertiary Strata of Belgium.* *By* E. van den Broek.

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3. *On the Discovery of Fossil Elephant Remains at Tilloun (Charente).* *By* Marcellin Boule.

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4. *On Earth Movements observed in Japan.* *By* J. Milne, *F.R.S.*

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5. *Reports on the Volcanic and Seismological Phenomena of Japan.* See Reports, pp. 81, 113.

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6. *Final Report on the Volcanic Phenomena of Vesuvius.* See Reports, p. 351.

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7. *Report on Earth Tremors.*—See Reports, p. 184.

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8. *Interim Report on the Investigation of a Coral Reef.* See Reports, p. 392.

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9. *Report on Geological Photographs.*—See Reports, p. 404.

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10. *The Auriferous Conglomerates of the Witwatersrand, Transvaal.* *By* Frederick H. Hatch, *Ph.D., F.G.S.*

The general geological features of these now famous deposits are more or less familiar to most readers. The beds of the 'Main Reef Series' have been closely studied from one end of the Rand to the other, and are now being worked in an almost continuous series of prosperous gold-mining companies, the whole distance covered by mines in active operation amounting to forty-six miles. The beds have the usual characteristics of conglomerates, being composed of pebbles which present every sign of having been water-rolled and worn smooth by attrition. The pebbles consist of white or smoky quartz, and lie imbedded in a sandy or quartzitic matrix. The older rocks, from the waste of which these conglomerates are derived, were probably members of the Primary Formation, on which the Witwatersrand beds lie. That these older rocks were largely veined with quartz is evident from the nature of the pebbles, and that they were not the source of the gold is evident from the fact that the quartz pebbles do not carry gold, the metallic contents being confined to the matrix.

There is little doubt that the gold was introduced subsequently to the deposition of the beds by means of mineralising solutions, which ascended the planes of disruption and fissuring which resulted from the disturbance of the beds during their upheaval. A considerable amount of basic igneous matter was also introduced, and now appears in the beds in the form of dykes and intrusive sheets.

The angle of dip of the auriferous beds at their outcrop is generally high (50°–80°), but the lowest workings of the mines evidence a considerable flattening of the deposits, the average dip in the lowest levels being at present not more than 30°. It is probable that the flattening will continue, and that the dip in the deep level workings will be found to be not more than 25°. As these deep levels will probably be worked to a vertical depth of 4,000 to 5,000 feet, the zone of workable auriferous deposit must be at least 1½ mile wide.

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11. *Report on the 'Stonesfield Slate.'*—See Reports, p. 414.

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12. *On the Strata of the Shaft sunk at Stonesfield, Oxon, in* 1895. *By* Edwin A. Walford, *F.G.S.*

Since 1860 no continuous section of the upper beds of the Inferior Oolite, and of the limestones intervening between them and the Stonesfield Slate, has been exposed in Oxfordshire. In 1860 but brief record seems to have been made of the character of the beds pierced.

The lower part of the section made by the aid of the British Association in 1894–95 resolves itself readily into three divisions:—

1. Compact buff-coloured limestones.
2. Sandstone and sandy limestones with vertical markings and borings.
3. Rubbly coarse-grained oolitic limestone (Clypeus Grit) zone *Ammonites Parkinsoni.*

Series 1 extends to the north-west as far as Long Compton, in Warwickshire, and on the north to Sibford in Oxfordshire. Around Chipping Norton it is best developed, but its vertical boundaries are hardly determinable. I take it to represent the Fullonian clays and limestones of the South and South-west of England. Just as at Port-en-Bessin and Caen, in Normandy, we see at one place the argillaceous and argillaceo-calcareous series, and at the other the calcareous and siliceo-calcareous series, so also from west to east in England the deposits change from argillaceous to calcareous, and with a poorer fauna.

Series 2, generally underlying the limestones, may be traced as far as Banbury, and has a wide range over Northamptonshire. A bed of Trigonia (*T. signata*) marks is found around Hook Norton, Chipping Norton, and Long Compton, the lower part of the sandy series, with *Ammonites Parkinsoni* and remains of marsh plants. The higher sandy limestones are recognised by the presence of long annulated stems of Algæ (?), extending also through the Northamptonshire deposits, and characterising the higher beds there. The blue and white sandy limestone of Stonesfield is full of vertical markings of plants—markings which are prominent in every section of the 'Estuarine' sands of Northamptonshire. The succession of these to the bed with *Trigonia signata* may be seen in a quarry at Sharpshill, between Brailes and Hook Norton, where a well-marked band of siliceous limestone with *Trigonia signata*, Ag., *T. Lycetti*, Walf, is covered with two feet of shattered siliceous stone pierced with vertical markings. These are the Oxfordshire representatives of the Northamptonshire Estuarine Sands.

So far, then, the Stonesfield section enables us to get a better understanding of the relationships of the Oxfordshire and Northamptonshire Inferior Oolite.

Though the zones of the Northamptonshire Inferior Oolite appear at present to be ill-defined, we may hope in Sharpe's Series D to recognise the representative of the well-known Clypeus grit of West Oxfordshire and the Cotteswolds.

TUESDAY, SEPTEMBER 17.

The following Papers and Reports were read:—

1. *The Trial-boring at Stutton. By* W. WHITAKER, *F.R.S.*

This, the first attempt of the Eastern Counties Coal-boring Association, is in the low ground southward of Crepping Hall, and has been successful in reaching the base of the Cretaceous beds at the depth of 994 feet, and in proving that these are at once underlain by a much older rock. The Tertiary and Cretaceous beds passed through are as follows:—

	Feet
Drift (River Gravel)	16
London Clay and Reading Beds	54
Upper and Middle Chalk	720
Lower Chalk, with very glauconitic marl at the base (almost a greensand)	154½
Gault	49½

Beneath this is Palæozoic rock, with a high dip, which has been pierced to the depth of over 200 feet.

The thickness of both Chalk and Gault is slightly less than at Harwich, and there is also a little less of the Tertiary beds.

A full account will be brought before the Geological Society.

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2. *The Dip of the Underground Palæozoic Rocks at Ware and at Cheshunt. By* JOSEPH FRANCIS, *M.Inst.C.E.*

Ordered to be printed *in extenso*.—See Reports, p. 441.

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3. *On the Importance of extending the Work of the Geological Survey of Great Britain to the Deep-seated Rocks by means of Boring. By* F. W. HARMER, *F.G.S.*

The systematic exploration of the subterranean geology of these islands is equally important from a scientific and a practical point of view. At present our knowledge of the structure of the rocks which form the foundation of our island home is due either to isolated and occasional borings, such as that of the Ipswich Syndicate in search of coal, or to deep wells sunk by mercantile firms, but the latter do not reach further than is necessary to obtain a supply of water, and the work is generally suspended just where it becomes geologically most interesting. But such a Survey is important practically, because unsuspected sources of wealth may be hidden under our very feet.

It is a mistake to suppose that a discovery such as that of a new coal-field would enrich only the landowners of the district, because whenever any appreciation of real property takes place, the State at once claims its share of the increased value, both for imperial and local purposes. The average for the whole country of the rates raised by local taxation alone was, for 1891, 3*s.* 8*d.* in the £, to which must be added imperial taxes and the tithe. It may be stated roughly, that for every 100*l.* of yearly 'unearned increment' the State is benefited in one way or another by 25*l.*, or one-fourth of the amount. The discovery of a new coal-field would cause increased prosperity in the district in which it occurred, and from this the State, through taxation, would derive great though indirect advantage.

The growing difficulty of finding employment for the ever-increasing population of these islands is a strong reason why this Survey should be undertaken.

Part of the cost might be borne by the landowners under whose property any minerals were discovered. Certain districts should be selected with the consent of the Local Authorities, and Parliamentary power taken to charge a royalty on any minerals obtained below a certain depth. Landowners would probably welcome proposals to make borings on their estates on such conditions. In the first instance, however, the Survey should map out accurately the subterranean limits of existing coal-fields, or mineral-bearing rocks, but trial borings should be put down in different localities, and each new boring would help to show more plainly the direction in which further investigations should be made. Much light would be thrown by such a Survey on the circulation of underground waters, a matter of great practical importance.

The expense of boring would be much reduced if undertaken on a large scale, as machinery and apparatus would be available again and again. The Survey would employ its own workmen, who would become increasingly efficient and economical.

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4. *The Cladodonts of the Upper Devonian of Ohio.* *By* Professor E. W. Claypole, *D.Sc.* (*Lond.*)

Numerous specimens of the Cladodonts of the Cleveland Shale in Ohio have been found by Dr. William Clark. They for the first time reveal to us the general form of the fishes to which belonged the teeth that have alone so long represented the genus *Cladodus.* The fossils are in very fair preservation, but their state of pyritisation has obscured many of the details of their structure. So far as regards their form, however, we now know that they were long, slender fishes, resembling in their character the sharks of the present day; that they possessed well-developed and powerful pectoral and caudal, with weak ventral, fins, the dorsals being unknown; that they were for the most part, or altogether, spineless; that at least one species possessed cladadont teeth of more than one pattern; and that they had near the hind end of the body a peculiar flat expansion or membrane of rudely semicircular form, which gave to the caudal extremity when seen from above the outline of a sharp-pointed shovel.

The largest whole specimen yet found shows a fish of about 6 feet in length, but detached teeth and other fragments indicate others of double this size, and supply abundant proof that in late Devonian times, and in the North American area, the elasmobranch fishes had attained very great proportions and a high stage of development.

Hitherto the Cladodonts have been regarded as, in the main, characterising the Lower Carboniferous rocks, but we now find them abounding in the earlier Devonian strata, and, as shown by the contents of their stomachs, preying—in some cases at least—on the smaller placoderms of the same area.

From the evidence of the new specimens it appears most likely that the species already defined from single and isolated teeth can no longer be maintained.

For details see the author's papers in the 'American Geologist' for 1893–4–5.

5. *The Great Devonian Placoderms of Ohio, with Specimens. By* Professor E. W. Claypole, *D.Sc.* (*Lond.*)

The Upper Devonian Shales of Ohio have recently afforded a remarkable series of fossil fishes rivalling in size and interest those found many years ago in the Old Red Sandstones of similar age in Scotland, and described by Agassiz and Hugh Miller. The earliest of these, *Dinichthys,* was closely studied, and its structure was well explained by the late Dr. Newberry. It was an immense armour-clad fish whose head measured from 2 to 3 feet in length. *Titanichthys,* the second of the group, though less massive, was of yet larger size. *Gorgonichthys,* the third, was described by the present writer in 1893, and, so far as is yet known, was the most formidable of all, possessing jaws of enormous size and thickness, above 24 inches long, ending in teeth or points from 6 to 9 inches in length. The last of the four, *Brontichthys,* of which a description was also published by the writer in the 'American Geologist' for 1894, is equally heavy and of equal size, but differs from all the rest in possessing very massive symphysial portions in the mandibles with sockets apparently for the reception of teeth, as in *Titanichthys.*

Of the two last-named genera only the jaws are yet known with exactness. Other portions have been found of *Gorgonichthys,* but are still embedded in the matrix. So far as can at present be determined, all the four are closely allied to *Coccosteus,* and belong to the same family.

The set of casts exhibited in illustration of the fossils have been prepared by their discoverer, Dr. William Clark, and faithfully represent the originals, of many of which only single specimens are yet known. The labour of extricating them from the pyritous shale has proved very heavy, and much yet remains to be done in this direction.

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6. *Notes on the Phylogeny of the Graptolites. By* Prof. H. A. Nicholson, *M.D., D.Sc., F.G.S., and* J. E. Marr, *M.A., F.R.S., Sec. G.S.*

The authors note that the number of stipes possessed by graptolites has been looked upon as a character of prime importance, many genera being based on the possession of a certain number. Again, the 'angle of divergence' has been looked upon as an important factor in the diagnosis of families. They are, however, led to believe that a character of essential importance in dealing with the classification of the graptolites, and one which, in all probability, indicates the true line of descent, is found in the shape and structure of the hydrothecæ, the point of next importance as indicating genetic relationship being the 'angle of divergence.'

These views are illustrated by reference to forms belonging to the 'genera' *Bryograptus, Dichograptus, Tetragraptus,* and *Didymograptus,* which appear in turn in this sequence.

Out of nine *Tetragrapti* (and the authors know of no other forms referred to this genus which are represented by well-preserved examples), eight are closely represented by forms of *Didymograptus,* which are closely comparable with them as regards characters of hydrothecæ and amount of 'angle of divergence,' whilst the ninth is comparable with a *Didymograptus* as regards 'angle of divergence' only. Moreover, four of the *Tetragrapti* are comparable as regards the two above-named important characters with forms of *Dichograptus* and *Bryograptus* with eight or more branches, and the authors confidently predict the discovery of forms belonging to these or closely allied many-branched 'genera,' agreeing with the remaining *Tetragrapti* in what they regard as essential characters.

They give details showing the points of agreement of each group of the various series, including a two-branched, a four-branched, and a many-branched form, and point out how difficult it is to understand how the extraordinary resemblances between the various species of *Tetragraptus* and *Didymograptus* (to take one example) have arisen, if, as usually supposed, all the species of the genera have descended from a common ancestral form for each genus, in the one case four-branched, and in the other case two-branched. On the other hand, it is comparatively easy to explain the more or less simultaneous existence of forms possessing the same number of stipes, but otherwise only distantly related, if they are imagined to be the result of the variation of a number of different ancestral types along similar lines. They allude to similar phenomena which have been shown to exist amongst other organisms; thus Mojsisovics has described analogous cases amongst the Ammonites, and Buckman (under the name of heterogenetic homœomorphy) amongst the brachiopods, though in this instance the cases of 'species' and not of 'genera' are considered.

Following the above inferences to their legitimate conclusion, the authors point out how 'genera' like *Diplograptus* and *Monograptus* may contain representatives of more than one 'family' of graptolites, according to the classification now in vogue, which would account for the great diversity in the characters of the monograptid hydrothecæ.

In conclusion, the authors offer a few theoretical observations upon a possible reason for the changes which they have discussed in the paper.

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7. *Zonal Divisions of the Carboniferous System. By* E. J. Garwood, *M.A., F.G.S., and* J. E. Marr, *M.A., F.R.S.*

The authors call attention to previous attempts which have been made to divide the Carboniferous rocks into zones, noting the zonal divisions of the Lower Carboniferous rocks of North England, established by De Koninck and Lohest, and the view expressed by Waagen that fuller work will enable geologists to define a series of zones in the Carboniferous as in older and newer strata.

The detailed work of one of the authors (Mr. Garwood) leads them to suppose that the following zones occur in the Lower Carboniferous beds of the northern part of the Pennine Chain and adjoining regions:—

Zone of Productus *cf.* edelburgensis.
 „ P. latissimus.
 „ P. giganteus.
 „ Chonetes papilionacea.
 „ Spirifera octoplicata.

Mr. Garwood has traced the zone of *Productus latissimus*, occupying the same relative position to that of *P. giganteus*, from Settle, in Yorkshire, to the Northumbrian coast, near Howick Burn.

The authors believe that brachiopods and goniatites will furnish good results, if a detailed study of their distribution is made; and they suggest that a Committee be appointed to inquire into the possibility of dividing the Carboniferous rocks into zones, to call the attention of local observers to the desirability of collecting fossils with this view, and, if possible, to retain the services of eminent specialists, to whom these fossils may be submitted.

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8. *Twelfth Report on Palæozoic Phyllopoda.*—See Reports, p. 416.

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9. *Interim Report on the Eurypterid-bearing Deposits of the Pentland Hills.*

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10. *On some Decapod Crustacea from the Cretaceous Formation of Vancouver's Island, &c. By* Henry Woodward, *F.R.S.*

Through the kindness of Mr. J. F. Whiteaves, F.G.S., Palæontologist to the Geological Survey of Canada, I have lately received a series of Crustacea from Vancouver Island and Queen Charlotte Island, and as they offer a close affinity with forms from our Gault and Greensand, they seem deserving of special notice.

The existence of Cretaceous beds in Canada has long been known, and the coalfields of Nanaimo and Comox, on Vancouver Island, have been correlated with the Cretaceous series, as well as those of Queen Charlotte Island, and that of Alberta eastward of the Rocky Mountains.

The fossils were described by F. B. Meek in 1857, by Dr. B. F. Shumard in 1858, by Professor H. Y. Hind in 1859, Dr. Hector in 1861, Mr. W. Gabb in 1864. These are all descriptions of characteristic Cretaceous mollusca. Only two Crustacea are mentioned, namely, a decapod crustacean, provisionally named *Hoploparia Dulmenensis*, from the Niobara-Beaton group of Manitoba, and a long-tailed decapod from the Pierre-Fox Hills, or Montana formation. These have not been seen by the present writer.

The species now recorded comprise—

1. *Several examples* of a small burrowing form of decapod-macrouran crustacean, belonging to the *Callianassidæ*, and common in the chalk of Maastricht and Faxoe, and the Greensand of Colin Glen, Belfast.

The Vancouver Island form is named *Callianassa Whiteavesii.*

2. The second is a form of brachyuran decapod, belonging to the family *Corystidæ*, and is represented by two imperfect carapaces, one of which shows the frontal portion well preserved, and is evidently closely related to the genera *Eucorystes* and *Palæocorystes* from the Greensand and Gault of England, and especially with *Palæocorystes Broderipi*, from the Gault of Folkestone. I propose to name this after the discoverer as *Palæocorystes Harveyi*. The specimens were obtained from the Cretaceous beds of Comox River, Vancouver Island.

3. This form is the most abundant of the crabs met with, and is nearly allied to *Plagiophthalmus*, but its exact position is somewhat doubtful.

Mr. Harvey writes that he has found this small crab everywhere in the district of Vancouver's Island, where there are marine Cretaceous beds and fossils. I have named it (provisionally) *Plagiophthalmus* (?) *vancouverensis.*

4. The fourth specimen is a crab allied to the genus *Homola*, and is from Queen Charlotte Island, Skidegate Channel, west of Alliford Bay, and was obtained by Mr. J. Richardson. It may be compared with the genus *Prosopon* (von Meyer), from the Jurassic, with several forms from the Chalk of Faxoe, and with *Homolopsis Edwardsii*, from the Gault of Folkestone. I have named it (provisionally) *Homolopsis* (?) *Richardsoni*, after the discoverer.

These crabs occur in concretionary nodules in the Cretaceous beds of Vancouver, and in black coarse nodules on the beach at Queen Charlotte Island, but they have not been removed far from the parent rock.

It is interesting to notice the close approximation between these North-West American Cretaceous forms of Crustacea and those from the same horizon in Europe, and it seems to indicate that even so late as Cretaceous times the same marine fauna existed over a far wider area than it at present covers. This is true, also, of the abundant molluscan fauna occurring in the same series of beds over very widely separated areas of the North American continent, from Manitoba in the east to Vancouver in the west, many of the genera (and perhaps the species also) being found in our own Cretaceous beds.

[Diagrams of the new forms were exhibited.]

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11. *Interim Report on the Registration of Type Specimens.*

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12. *Twenty-third Report on Erratic Blocks.*—See Reports, p. 430.

SECTION D.—ZOOLOGY (INCLUDING ANIMAL PHYSIOLOGY).

PRESIDENT OF THE SECTION—WILLIAM A. HERDMAN, D.Sc., F.R.S., F.R.S.E., F.L.S., Professor of Natural History in University College, Liverpool.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

THIS year, for the first time in the history of the British Association, Section D meets without including in the range of its subject-matter the Science of Botany. Zoology now remains as the sole occupant of Section D—that 'Fourth Committee of Sciences,' as it was at first called, more than sixty years ago, when our subject was one of that group of biological sciences, the others being Botany, Physiology, and Anatomy. These allied sciences have successively left us. Like a prolific mother our Section has given rise one after another to the now independent Sections of Anthropology, Physiology, and Botany. Our subject-matter has been greatly restricted in scope, but it is still very wide—this year, when Section I devoted to the more special physiology of the medical physiologist does not meet, perhaps a little wider than it may be in other years, since we are on this occasion credited with the subject 'Animal Physiology'—surely *always* an integral part of Zoology! It is to be hoped that this section will always retain that general and comparative physiology which is inseparable from the study of animal form and structure. The late Waynflete Professor of Physiology at Oxford, in his Newcastle Address to this Section, said 'that every appreciable difference in structure corresponds to a difference of function,'[1] and his successor, the present Waynflete Professor, has shown us 'how pointless is structure apart from function, and how baseless and unstable is function apart from structure'[2]—the 'argument for the simultaneous examination of both' in that science of Zoology which we profess is, to my mind, irresistible.

We include also in our subject-matter, besides the adult structure and the embryonic development of animals, their distribution both in space and time, the history and structure of extinct forms, speciography and classification, the study of the habits of animals and all that mass of lore and philosophy which has gathered around inquiries into instinct, breeding, and heredity. I trust that the discussion of matters connected with Evolution will always, to a large extent, remain with this Section D, which has witnessed in the past the addresses, papers, discussions, and triumphs of Darwin, Huxley, and Wallace.

When the British Association last met in Ipswich, in 1851, Section D, under the Presidency of Professor Henslow, still included Zoology, Botany, and Physiology, and a glance through the volumes of reports for that and neighbouring years

[1] Burdon-Sanderson—*British Association Report* for 1889.
[2] Gotch—Presidential Address to *Liverpool Biological Society*, vol. ix. 1894.

recalls to us that our subject has undergone great and striking developments in the forty-four years that have elapsed. Zoology was still *pre-Darwinian* (though Charles Darwin was then in the thick of his epoch-making work—both what he calls his 'plain barnacle work' and his 'theoretic species work').[1] Although the cell-theory had been launched a decade before, zoologists were not yet greatly concerned with those minute structural details which have since built up the science of Histology. The heroes of our science were then chiefly those glorious field naturalists, observers, and systematists who founded and established on a firm basis British Marine Zoology. Edward Forbes, Joshua Alder, Albany Hancock were then in active work. George Johnston was at his zoophytes, Bowerbank at sponges, Busk at polyzoa. Forbes' short brilliant career was nearly run. He probably did more than any of his contemporaries to advance marine zoology. In the previous year, at the Edinburgh meeting of the Association, he and his friend McAndrew, had read their classic reports,[2] 'On the Investigation of British Marine Zoology by means of the Dredge,' and 'On South European Marine Invertebrata,' which mark the high water level reached at that date, and for some time afterwards, in the exploration of our coasts and the explanation of the distribution of our marine animals. At the Belfast meeting, which followed Ipswich, Forbes exhibited his great map of the distribution of marine life in 'Homoiozoic Belts.' In November, 1854, he was dead, six months after his appointment to the goal of his ambition, the professorship at Edinburgh, where, had he lived, there can be no doubt he would, with his brilliant ability and unique personality, have founded a great school of Marine Zoology.

To return to the early fifties, Huxley—whose recent loss to science, to philosophy, to culture, we, in common with the civilised world, now deplore—at that time just returned from the memorable voyage of the 'Rattlesnake,' was opening out his newly acquired treasures of comparative anatomy with papers on Siphonophora and on Sagitta, and one on the structure of Ascidians, in which he urged—fourteen years before Kowalevsky established it on embryological evidence in 1866—that their relations were with Amphioxus, as we now believe, rather than with the Polyzoa or the Lamellibranchiata, as had formerly been supposed. Bates was then on the Amazons, Wallace was just going out to the Malay Archipelago, Wyville Thomson, Hincks, and Carpenter, the successors of Forbes, Johnston, and Alder, were beginning their life-work. Abroad that great teacher and investigator, Johannes Müller, was training amongst his pupils the most eminent zoologists, anatomists, and physiologists of the succeeding quarter century. In this country, as we have seen, Huxley was just beginning to publish that splendid series of researches into the structure of nearly all groups in the animal kingdom, to which comparative anatomy owes so much.

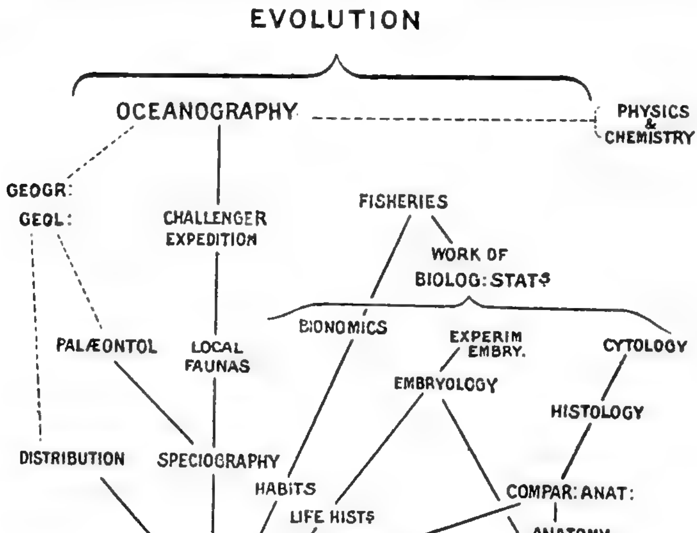
In fact, the few years before and after the last Ipswich meeting witnessed the activity of some of the greatest of our British zoologists—the time was pregnant with work which has since advanced, and in some respects revolutionised our subject. It was then still usual for the naturalist to have a competent knowledge of the whole range of the natural sciences. Edward Forbes, for example, was a botanist and a geologist, as well as a zoologist. He occupied the chair of Botany at King's College, London, and the presidential chair of the Geological Section of the British Association at Liverpool in 1854. That excessive specialisation, from which most of us suffer in the present day, had not yet arisen; and in the comprehensive, but perhaps not very detailed, survey of his subject taken by one of the field naturalists of that time, we find the beginnings of different lines of work, which have since developed into some half-dozen distinct departments of zoology, are now often studied independently, and are in some real danger of losing touch with one another (see diagram).

The splendid anatomical and 'morphological' researches of Huxley and Johannes Müller have been continued by the more minute histological or cellular work rendered possible by improvements of the microtome and the microscope,

[1] See *Life and Letters*, vol. i. p. 380.
[2] *British Association Report* for 1850, p. 192—*et seq.*

until at last in these latter years we investigate not merely the cellular anatomy of the body, but *the anatomy of the cell*—if indeed we are permitted to talk of 'cell' at all, and are not rather constrained to express our results in terms of 'cytomicrosomes,' 'somacules,' or 'idiosomes,' and to regard our morphological unit, the cell, as a symbiotic community containing two colonies of totally dissimilar organisms.[1] To such cytological investigations may well be applied Lord Macaulay's aphorism, 'A point which yesterday was invisible is its goal to-day, and will be its starting point to-morrow.'

Somewhat similar advances in methods have led us from the life-histories studied of old to the new and fascinating science of embryology. The elder Milne-Edwards and Van Beneden knew that in their life-histories Ascidians produced tadpole-like young. Kowalevsky (1866) showed that in their embryonic stages these Ascidian tadpoles have the beginnings of their chief systems of organs formed in essentially the same manner and from the same embryonic layers as in the case of the frog's tadpole or any other typical young vertebrate; and now we are not content with less than tracing what is called the 'cell-lineage' of such Ascidian embryos, so as to show the ancestry and descendants, the traditions peculiarities of, and influences at work upon each of the embryonic cells—or areas of protoplasm—throughout many complicated stages. And there is now opening



up from this a great new field of experimental and 'mechanical' embryology, in which we seek the clue to the explanation of particular processes and changes by determining under what conditions they take place, and how they are affected by altered conditions. We are brought face to face with such curious problems as, Why does a frog's egg, in the two-celled stage, of which one half has been destroyed, develop into half an embryo when it is kept with one (the black) surface uppermost, and into—not half an embryo, but—a whole embryo of *half the usual size* if kept with the other (the white) surface upwards. Apparently, according to the conditions of the experiment, we may get half embryos or whole embryos of half size from one of the first two cells of the frog's egg.[2]

One of the most characteristic studies of the older field naturalists, the observation of habits, has now become, under the influence of Darwinism, the 'Biono-

[1] See Watasé in *Wood's Holl Biological Lectures*, 1893.

[2] See Morgan, *Anat. Anzeig.*, 1895, x. Bd. p. 623, and recent papers by Roux, Hertwig, Born, and O. Schultze.

mics' of the present day, the study of the relations between habit and structure and environment—a most fascinating and promising field of investigation, which may be confidently expected to tell us much in the future in regard to the competition between species, and the useful or indifferent nature of specific characters.

Other distinct lines of zoological investigation, upon which I shall not dwell, are geographical distribution and palæontology—subjects in which the zoologist comes into contact with, and may be of some service to his fellow-workers in geology. And there still remains the central avenue of the wide zoological domain—that of speciography and systematic zoology—which has been cultivated by the great classifiers and monographers from Linnæus to Haeckel, and has culminated in our times in the magnificent series of fifty quarto volumes, setting forth the scientific results of the 'Challenger' Expedition; a voyage of discovery comparable only in its important and wide-reaching results with the voyages of Columbus, Gama, and Magellan at the end of the fifteenth century. It is now so long since the 'Challenger' investigations commenced that few I suppose outside the range of professional zoologists are aware that, although the expedition took place in 1872 to 1876, the work resulting therefrom has been going on actively until now—for nearly a quarter of a century in all—and in a sense, and a very real one, will never cease, for the 'Challenger' has left an indelible mark upon science, and will remain through the ages exercising its powerful, guiding influence, like the work of Aristotle, Newton, and Darwin.

Most of the authors of the special memoirs on the sea and its various kinds of inhabitants, have interpreted in a liberal spirit the instructions they received to examine and describe the collections entrusted to them, and have given us very valuable summaries of the condition of our knowledge of the animals in question, while some of the reports are little less than complete monographs of the groups. I desire to pay a tribute of respect to my former teacher and scientific chief, Sir Wyville Thomson, to whose initiative, along with Dr. W. B. Carpenter, we owe the first inception of our now celebrated deep-sea dredging expeditions, and to whose scientific enthusiasm, combined with administrative skill, is due in great part the successful accomplishment of the 'Lightning,' the 'Porcupine,' and the 'Challenger' Expeditions. Wyville Thomson lived long enough to superintend the first examination of the collections brought home, their division into groups, and the allotment of these to specialists for description. He enlisted the services of his many scientific friends at home and abroad, he arranged the general plan of the work, decided upon the form of publication, and died in 1882 after seeing the first ten or twelve zoological reports through the press.

Within the last few months have been issued the two concluding volumes of this noble series, dealing with a summary of the results, conceived and written in a masterly manner by the eminent editor of the reports, Dr. John Murray. An event of such first-rate importance in zoology as the completion of this great work ought not to pass unnoticed at this zoological gathering. I desire to express my appreciation and admiration of Dr. Murray's work, and I do not doubt that the Section will permit me to convey to Dr. Murray the congratulations of the zoologists present, and their thanks for his splendid services to science. Murray, in these 'Summary' volumes, has given definiteness of scope and purpose, and a tremendous impulse, to that branch of science—mainly zoological—which is coming to be called

Oceanography.

Oceanography is the meeting ground of most of the sciences. It deals with botany and zoology, 'including animal physiology'; chemistry, physics, mechanics, meteorology, and geology all contribute, and the subject is of course intimately connected with geography, and has an incalculable influence upon mankind, his distribution, characteristics, commerce, and economics. Thus oceanography, one of the latest developments of marine zoology, extends into the domain of, and ought to find a place in, every one of the sections of the British Association.

Along with the intense specialisation of certain lines of zoology in the last quarter of the nineteenth century, it is important to notice that there are also lines of investigation which require an extended knowledge of, or at least make use of the results obtained from, various distinct subjects. One of these is oceanography, another is bionomics, which I have referred to above, a third is the philosophy of zoology, or all those studies which bear upon the theory of evolution, and a fourth is the investigation of practical fishery problems—which is chiefly an application of marine zoology. Of these four subjects—which while analytic enough in the detailed investigation of any particular problem, are synthetic in drawing together and making use of the various divergent branches of zoology and the neighbouring sciences—oceanography, bionomics, and the fisheries' investigation, are most closely related, and I desire to devote the remainder of this Address to the consideration of some points in connection with their present position.

Dr. Murray, in a few only too brief paragraphs at the end of his detailed summary of the results of the 'Challenger' Expedition, which I have alluded to above, states some of the views, highly suggestive and original, at which he has himself arrived from his unique experience. Some of his conclusions are very valuable contributions to knowledge, which will no doubt be adopted by marine zoologists. Others, I venture to think, are less sound and well founded, and will scarcely stand the test of time and further experience. But for all such statements, or even suggestions, we should be thankful. They do much to stimulate further research; they serve, if they can neither be refuted nor established, as working hypotheses; and even if they have to be eventually abandoned, we should bear in mind what Darwin has said as to the difference in their influence on science between erroneous facts and erroneous theories. 'False facts are highly injurious to the progress of science, for they often endure long; but false views, if supported by some evidence, do little harm, for everyone takes a salutary pleasure in proving their falseness; and when this is done, one path towards error is closed, and the road to truth is often at the same time opened.'[1]

With all respect for Murray's work, and fully conscious of my own temerity in venturing to differ from one who has had such an extended experience of the sea and its problems, I am constrained to express my disagreement with some of his conclusions. And I am encouraged to do so by the belief that Murray will rightly feel that the best compliment which zoologists can pay to his work is to give it careful, detailed consideration, and discuss it critically. He will, I am sure, join me in the hope that, whether his views or mine prove the false ones, we may be able, by their discussion, to close a 'path towards error,' and possibly open 'the road to truth.'

One of the points upon which Murray lays considerable stress, and to the elaboration of which he devotes a prominent position in his 'General Observations on the Distribution of Marine Organisms,' is the presence of what he has called a 'mud-line' around coasts at a depth of about one hundred fathoms. It is the point 'at which minute particles of organic and detrital matters in the form of mud begin to settle on the bottom of the ocean.' He regards it as the great feeding ground, and a place where the fauna is most abundant, and from which there have hived off, so to speak, the successive swarms or migrations which have peopled other regions—the deep waters, the open sea, the shallow waters and the estuaries, fresh waters, and land. Murray thus gives to his mud-line both a present and an historic importance which can scarcely be surpassed in the economy of life on this globe. I take it that the historic and the present importance stand or fall together—that the evidence as to the origin of faunas in the past is derived from their distribution at the present day, and I am inclined to think that Murray's opinion as to the distribution of animals in regard to the mud-line is not entirely in accord with the experience of specialists, and is not based upon reliable statistics. Murray's own statement is[2] :—'A depth is reached along the Continental shores facing the great oceans immediately below which the conditions become nearly uniform in all parts of the world, and where the fauna likewise presents a great uniformity. This depth is usually not far above nor far below the 100-fathom

[1] Darwin, *The Descent of Man*, 2nd edit., 1882, p. 606.
[2] *Challenger Expedition Summary*, vol. ii. p. 1433.

line, and is marked out by what I have elsewhere designated as the *Mud-line*. . . .' 'Here is situated the great feeding ground in the ocean . . .' and he then goes on (page 1434) to enumerate the Crustaceans, such as species of *Calanus, Euchæta, Pasiphæa, Crangon, Calocaris, Pandalus, Hippolyte,* many amphipods, isopods, and immense numbers of schizopods, which swarm, with fishes and cephalopods, immediately over this mud deposit. Now I venture to think that the experience of some of those who have studied the marine zoology of our own coasts does not bear out this statement. In the first place, our experience in the Irish Sea is that mud may be found at almost any depth, but is very varied in its nature and in its source. There may even be mud laid down between tide marks in an estuary where a very considerable current runs. A deposit of mud may be due to the presence of an eddy or a sheltered corner in which the finer particles suspended in the water are able to sink, or it may be due to the wearing away of a limestone beach, or to quantities of alluvium brought down by a stream from the land, or to the presence of a submerged bed of boulder clay, or even, in some places, to the sewage and refuse from coast towns. Finally, there is the deep water mud, a very stiff blue-grey substance which sets, when dried, into a firm clay, and this is, I take it, the mud of which Dr. Murray writes. But in none of these cases, and certainly not in the last mentioned, is there in my experience or in that of several other naturalists I have consulted, any rich fauna associated with the mud. In fact, I would regard mud as supporting a comparatively poor fauna as compared with other shallow water deposits.

For practical purposes, round our own British coasts, it is still convenient to make use of the zones of depth marked out by Forbes. The first of these is the 'Littoral zone,' the space between tide marks, characterised by the abundance of sea-weeds, belonging to the genera *Lichina, Fucus, Enteromorpha, Polysiphonia,* and others, and by large numbers of individuals belonging to common species of *Balanus, Mytilus, Littorina, Purpura,* and *Patella* amongst animals. The second zone is the 'Laminarian,' which extends from low water mark to a depth of a few fathoms, characterised by the abundant growth of large sea-weeds belonging to the genera *Laminaria, Alaria,* and *Himanthalia,* and by the presence of the beautiful red sea-weeds (Florideæ). There is abundance of vegetable food, and animals of all groups swarm in this zone, the numbers both of species and of individuals being very great. The genera *Helcion, Trochus,* and *Lacuna* are characteristic molluscan forms in our seas. Next comes Forbes' 'Coralline' zone, badly so named, extending from about ten to forty or fifty fathoms or so. Here we are beyond the range of the ordinary sea-weeds, but the calcareous, coral-like Nullipores are present in places in such abundance as to make up deposits covering the floor of the sea for miles. Hydroid zoophytes and polyzoa are also abundant, and it is in this zone that we find the shell-beds lying off our coasts, produced by great accumulations of species of *Pecten, Ostrea, Pectunculus, Fusus* and *Buccinum,* and forming rich feeding grounds for many of our larger fishes. All groups of marine animals are well represented in this zone, and *Antedon, Ophiothrix, Ophioglypha, Ebalia, Inachus,* and *Eurynome,* may be mentioned as characteristic genera. Lastly, there is what may be appropriately called the zone of deep mud (although Forbes did not call it so), extending from some fifty fathoms down to (in our seas) one hundred or so. The upper limit of this zone is Murray's mud-line. We come upon it in the deep fjord-like sea-lochs on the west of Scotland, and in the Irish Sea to the west of the Isle of Man.

Now of these four zones, my experience is that the last—that of the deep mud—has by far the poorest fauna both in species and in individuals. The mud has a *peculiar* fauna and one of great interest to the zoologist, but it is not a *rich* fauna. It contains some rare and remarkable animals not found elsewhere, such as *Calocaris macandreæ, Panthalis oerstedi, Lipobranchius jeffreysi, Brissopsis lyrifera, Amphiura chiajii, Isocardia cor,* and *Sagartia herdmani*; and a few striking novelties have been described from it of late years, but we have no reason to believe that the number of these is great compared with the number of animals obtained from shallower waters.

Dr. Murray not only insists upon the abundance of animals on the mud, and its importance as the great feeding ground and place of origin of life in the ocean, but he also (p. 1432) draws conclusions as to the relative numbers of animals taken by a single haul of the trawl in deep and shallow waters which can scarcely be received, I think, by marine zoologists without a protest. His statement runs (p. 1432): 'It is interesting to compare single hauls made in the deep sea and in shallow water with respect to the number of different species obtained. For instance, at station 146 in the Southern Ocean, at a depth of 1,375 fathoms the 200 specimens captured belonged to 59 genera and 78 species.' That was with a 10-foot trawl dragged for at most two miles during at most two hours. Murray then goes on to say: 'In depths less than 50 fathoms, on the other hand, I cannot find in all my experiments any record of such a variety of organisms in any single haul even when using much larger trawls and dragging over much greater distances.' He quotes the statistics of the Scottish Fishery Board's trawlings in the North Sea, with a 25 ft. trawl, to show that the average catch is 7·3 species of invertebrata and 8·3 species of fish, the greatest number of both together recorded in one haul being 29 species. Murray's own trawlings in the West of Scotland gave a much greater number of species, sometimes as many as 50, 'still not such a great variety of animals as was procured in many instances by the "Challenger's" small trawl in great depths.'

Now, in the first place, it is curious that Murray's own table on p. 1437, in which he shows that the 'terrigenous' deposits lying along the shore-lines yield many more animals, both specimens and species, per haul, than do the 'pelagic' deposits[1] at greater depths, such as red clays and globigerina oozes, seems directly opposed to the conclusion quoted above. In the second place, I am afraid that Dr. Murray has misunderstood the statistics of the Scottish Fishery Board when he quotes them as showing that only 7·3 or so species of invertebrates are brought up, on the average, in the trawl net. I happen to know from Mr. Thomas Scott, F.L.S., the naturalist who has compiled the statistics in question, and also from my own observations when on board the 'Garland' on one of her ordinary trawling expeditions, that the invertebrata noted down on the station sheet are merely a few of the more conspicuous or in other ways noteworthy animals. No attempt is made—nor could possibly be made in the time—by the one naturalist who has to attend to tow-nets, water bottle, the kinds, condition, food, &c., of the fish caught and other matters—to give anything like a complete or even approximate list of the species, still less the number of individuals, brought up in the trawl. I submit, therefore, that it is entirely misleading to compare those Scottish Fishery Board statistics, which were not meant for such a purpose but only to give a rough idea of the fauna associated with the fish upon certain grounds, with the carefully elaborated results, worked out at leisure by many specialists in their laboratories, of a haul of the 'Challenger's' trawl. Of Dr. Murray's own trawlings in the West of Scotland I cannot, of course, speak so positively, but I shall be surprised to learn that the results of each haul were as carefully preserved and as fully worked out by specialists as were the 'Challenger' collections.

Lastly, on the next L.M.B.C.[2] dredging expedition in the Irish Sea after the appearance of Dr. Murray's volumes, I set myself to determine the species taken in a haul of the trawl for comparison with the 'Challenger' numbers. The haul was taken on June 23, at 7 miles west from Peel, on the north bank, bottom sand and shells, depth 21 fathoms, with a trawl of only 4 ft. beam, less than half the size

[1] One of the earliest of the 'Challenger' oceanographic results, the classification of the submarine deposits into 'terrigenous' and 'pelagic,' seems inadequate to represent fully the facts in regard to sea-bottoms, so I am proposing elsewhere (*Report of Irish Sea Committee*) the following amended classification:—(1) Terrigenous (Murray), where the deposit is formed chiefly of mineral particles derived from the waste of the land; (2) Neritic, where the deposit is chiefly of organic origin, and is derived from the shells and other hard parts of the animals and plants living on the bottom; (3) Planktonic (Murray's 'pelagic'), where the greater part of the deposit is formed of the remains of free-swimming animals and plants which lived in the sea over the deposit.

[2] Liverpool Marine Biology Committee.

of the 'Challenger' one, and it was not down for more than twenty minutes I noted down the species observed, and I filled two bottles with undetermined stuff which my assistant, Mr. Andrew Scott, and I examined the following day in the laboratory. Our list comes to at least 112 species, belonging to at least 103 genera.[1] I counted 120 duplicate specimens which, added to 112, gives 232 individuals, but there may well have been 100 more. This experience, then, is very different from Murray's, and gives far larger numbers in every respect—specimens, species, and genera—than even the 'Challenger' deep-water haul quoted. I append my list of species,[2] and practised marine zoologists will, I think, see at a glance that it is nothing out of the way, that it is a fairly ordinary assemblage of not uncommon animals such as is frequently met with when dredging in the 'coralline' zone. I am sure that I have taken better netfuls than this both in the Irish Sea and on the West of Scotland.

In order to get another case on different ground, not of my own choosing, on the first occasion after the publication of Dr Murray's volumes when I was out witnessing the trawling observations of the Lancashire Sea Fisheries steamer 'John Fell,' I counted, with the help of my assistant, Mr. Andrew Scott, and the men on board, the results of the first haul of the shrimp trawl. It was taken at the mouth of the Mersey estuary, inside the Liverpool bar, on what the naturalist would consider very unfavourable ground, with a bottom of muddy sand, at a depth of 6 fathoms. The shrimp trawl ($1\frac{1}{2}$ in. mesh) was down for one hour, and it brought up over seventeen thousand specimens referable to at least 39 species,[3] belonging to 34 genera. These numbers have been exceeded on many other hauls taken in the ordinary course of work by the Fisheries steamer in Liverpool Bay—for example, on this occasion the fish numbered 5,943, and I have records of hauls on which the fish numbered over 20,000, and the total catch of individual animals must have been nearly 50,000. Can any of Dr. Murray's hauls on the deep mud beat these figures?

The conclusion, then, at which I arrive in regard to the distribution of animals in deep water and in water shallower than 50 fathoms, from my own experience and an examination of the 'Challenger' results, is in some respects the reverse of Murray's. I consider that there are more species and more individuals in the shallower waters, that the deep mud as dredged has a poor fauna, that the 'Coralline' zone has a much richer one, and that the 'Laminarian' zone, where there is vegetable as well as animal food, has probably the richest of all.

In order to come to as correct a conclusion as possible on the matter I have consulted several other naturalists in regard to the smaller groups of more or less free-swimming Crustacea, such as Copepoda and Ostracoda, which I thought might possibly be in considerable numbers over the mud. I have asked three well-known specialists on such Crustaceans—viz., Professor G. S. Brady, F.R.S., Mr. Thomas

[1] It is interesting, in connection with Darwin's opinion that an animal's most formidable competitors in the struggle for existence are those of its own kind or closely allied forms, to notice the large proportion of genera to species in such hauls. I have noticed this in many lists, and it certainly suggests that closely related forms are comparatively rarely taken together.

[2] See *Appendix*, p. 713.

[3]

Solea vulgaris	*Mytilus edulis*	*Dactylopus rostratus*
Pleuronectes platessa	*Tellina tenuis*	*Cletodes limicola*
P. limanda	*Mactra stultorum*	*Caligus*, sp.
Gadus morrhua	*Fusus antiquus*	*Flustra foliacea*
G. æglefinus	*Carcinus mænas*	*Aphrodite aculeata*
G. merlangus	*Portunus*, sp.	*Pectinaria belgica*
Clupea spratta	*Eupagurus bernhardus*	*Nereis*, sp.
C. harengus	*Crangon vulgaris*	*Asterias rubens*
Trachinus vipera	*Sacculina*, sp.	*Hydractinia echinata*
Agonus cataphractus	Some Amphipoda	*Sertularia abietina*
Gobius minutus	*Longipedia coronata*	*Hydrallmania falcata*
Raia clavata	*Ectinosoma spinipes*	*Aurelia aurita*
R. maculata	*Sunaristes paguri*	*Cyanæa*, sp.

Scott, F.L.S., and Mr. I. C. Thompson, F.L.S.—and they all agree in stating that, although interesting and peculiar, the Copepoda and Ostracoda from the deep mud are not abundant either in species or in individuals. In answer to the question which of the three regions (1) the littoral zone, (2) from low water to 20 fathoms, and (3) from 20 fathoms onwards, is richest in small free-swimming, but bottom-haunting, Crustacea, they all replied the middle region from 0 to 20 fathoms, which is the Laminarian zone and the upper edge of the Coralline. Professor Brady assures me that nearly every other kind of bottom and locality is better than mud for obtaining Ostracoda. Mr. T. Scott considers that Ostracoda are most abundant in shallow water, from 5 to 20 fathoms. He tells me that as the result of his experience in Loch Fyne, where a great part of the loch is deep, the richest fauna is always where banks occur, coming up to about 20 fathoms, and having the bottom formed of sand, gravel, and shells. The fauna on and over such banks, which are in the Coralline zone, is much richer than on the deeper mud around them. On an ordinary shelving shore on the west coast of Scotland Mr. Scott, who has had great experience in collecting, considers that the richest fauna is usually at about 20 fathoms. My own experience in dredging in Norway is the same. In the centre of the fjords in deep water on the mud there are rare forms, but very few of them, while in shallower water at the sides, above the mud, on gravel, shells, rock, and other bottoms, there is a very abundant fauna.

Probably no group of animals in the sea is of so much importance from the point of view of food as the Copepoda. They form a great part of the food of whales, and of herrings and many other useful fish, both in the adult and in the larval state, as well as of innumerable other animals, large and small. Consequently, I have inquired somewhat carefully into their distribution in the sea, with the assistance of Professor Brady, Mr. Scott, and Mr. Thompson. These experienced collectors all agree that Copepoda are most abundant, both as to species and individuals, close round the shore, amongst seaweeds, or in shallow water in the Laminarian zone over a weedy bottom. Individuals are sometimes extremely abundant on the surface of the sea amongst the plankton, or in shore pools near high water, where, amongst *Enteromorpha*, the Harpacticidæ swarm in immense profusion; but, for a gathering rich in individuals, species, and genera, the experienced collector goes to the shallow waters of the Laminarian zone. In regard to the remaining, higher, groups of the Crustacea my friend, Mr. Alfred O. Walker, tells me that he considers them most abundant at depths of 0 to 20 fathoms.

I hope no one will think that these are detailed matters interesting only to the collector, and having no particular bearing upon the great problems of biology. The sea is admittedly the starting-point of life on this earth, and the conclusions we come to as to the distribution of life in the different zones must form and modify our views as to the origin of the faunas—as to the peopling of the deep sea, the shallow waters, and the land. Murray supposes that life started in Pre-Cambrian times on the mud, and from there spread upwards into shallower waters, outwards on to the surface, and, a good deal later, downwards to the abysses by means of the cold Polar waters. The late Professor Moseley considered the pelagic or surface life of the ocean to be the primitive life from which all the others have been derived. Professor W. K. Brooks [1] considers that there was a primitive pelagic fauna, consisting of the simplest microscopic plants and animals, and 'that pelagic life was abundant for a long period during which the bottom was uninhabited.'

I, on the other hand, for the reasons given fully above, consider that the Laminarian zone close to low-water mark is at present the richest in life, that it probably has been so in the past, and that if one has to express a more definite opinion as to where, in Pre-Cambrian times, life in its simplest forms first appeared, I see no reason why any other zone should be considered as having a better claim than what is now the Laminarian to this distinction. It is there, at present at any rate, in the upper edge of the Laminarian zone, at the point of junction of sea,

[1] *The genus Salpa*, 1893, p. 156, &c.

land, and air, where there is a profusion of food, where the materials brought down by streams or worn away from the land are first deposited, where the animals are able to receive the greatest amount of light and heat, oxygen and food, without being exposed periodically to the air, rain, frost, sun, and other adverse conditions of the littoral zone, it is there that life—it seems to me—is most abundant, growth most active, competition most severe. It is there, probably, that the surrounding conditions are most favourable to animal life; and, therefore, it seems likely that it is from this region that, as the result of overcrowding, migrations have taken place downwards to the abysses, outwards on the surface, and upwards on to the shore. Finally, it is in this Laminarian zone, probably, that under the stress of competition between individuals and between allied species evolution of new forms by means of natural selection has been most active. Here, at any rate, we find, along with some of the most primitive of animals, some of the most remarkably modified forms, and some of the most curious cases of minute adaptation to environment. This brings us to the subject of

Bionomics,

which deals with the habits and variations of animals, their modifications, and the relations of these modifications to the surrounding conditions of existence.

It is remarkable that the great impetus given by Darwin's work to biological investigation has been chiefly directed to problems of structure and development, and not so much to bionomics until lately. Variation amongst animals in a state of nature is, however, at last beginning to receive the attention it deserves. Bateson has collected together, and classified in a most useful book of reference, the numerous scattered observations on variation made by many investigators, and has drawn from some of these cases a conclusion in regard to the discontinuity of variation which many field zoologists find it hard to accept.

Weldon and Karl Pearson have recently applied the methods of statistics and mathematics to the study of individual variation. This method of investigation, in Professor Weldon's hands, may be expected to yield results of great interest in regard to the influence of variations in the young animal upon the chance of survival, and so upon the adult characteristics of the species. But while acknowledging the value of these methods, and admiring the skill and care with which they have been devised and applied, I must emphatically protest against the idea which has been suggested, that only by such mathematical and statistical methods of study can we successfully determine the influence of the environment on species, gauge the utility of specific characters, and throw further light upon the origin of species. For my part, I believe we shall gain a truer insight into those mysteries which still involve variations and species by a study of the characteristic features of individuals, varieties, and species in a living state in relation to their environment and habits. The mode of work of the old field naturalists, supplemented by the apparatus and methods of the modern laboratory, is, I believe, not only one of the most fascinating, but also one of the most profitable, fields of investigation for the philosophical zoologist. Such studies must be made in that modern outcome of the growing needs of our science, the Zoological Station, where marine animals can be kept in captivity under natural conditions, so that their habits may be closely observed, and where we can follow out the old precept—first, Observation and Reflection; then Experiment.

The biological stations of the present day represent, then, a happy union of the field work of the older naturalists with the laboratory work of the comparative anatomist, histologist, and embryologist. They are the culmination of the 'Aquarium' studies of Kingsley and Gosse, and of the feeling in both scientific men and amateurs, which was expressed by Herbert Spencer when he said: 'Whoever at the seaside has not had a microscope and an aquarium has yet to learn what the highest pleasures of the seaside are.' Moreover, I feel that the biological station has come to the rescue, at a critical moment, of our laboratory worker who, without its healthy, refreshing influence, is often in these latter days in peril of losing his intellectual life in the weary maze of microtome methods and transcendental cytology. The old Greek myth of the Libyan giant, Antæus, who wrestled with Hercules and regained his strength each time he touched his mother earth, is true at least of the zoologist. I am sure he derives fresh vigour from every direct contact with living nature.

In our tanks and artificial pools we can reproduce the Littoral and the Laminarian zones; we can see the methods of feeding and breeding—the two most powerful factors in influencing an animal. We can study mimicry, and test theories of protective and warning colouration.

The explanations given by these theories of the varied forms and colours of animals were first applied by such leaders in our science as Bates, Wallace, and Darwin, chiefly to insects and birds, but have lately been extended, by the investigations of Giard, Garstang, Clubb, and others, to the case of marine animals. I may mention very briefly one or two examples. Amongst the Nudibranchiate Mollusca—familiar animals around most parts of our British coasts—we meet with various forms which are edible, and, so far as we know, unprotected by any defensive or offensive apparatus. Such forms are usually shaped or coloured so as to resemble more or less their surroundings, and so become inconspicuous in their natural haunts. *Dendronotus arborescens*, one of the largest and most handsome of our British Nudibranchs, is such a case. The large, branched processes on its back, and its rich purple-brown and yellow markings, tone in so well with the masses of brown and yellow zoophytes and purplish-red seaweeds, amongst which we usually find *Dendronotus*, that it becomes very completely protected from observation; and, as I know from my own experience, the practised eye of the naturalist may fail to detect it lying before him in the tangled forests of a shore-pool.

Other Nudibranchs, however, belonging to the genus *Eolis*, for example, are coloured in such a brilliant and seemingly crude manner, that they do not tone in with any natural surroundings, and so are always conspicuous. They are active in their habits, and seem rather to court observation than to shun it. When we remember that such species of *Eolis* are protected by the numerous stinging cells in the cnidophorous sacs placed on the tips of all the dorsal processes, and that they do not seem to be eaten by other animals, we have at once an explanation of their fearless habits and of their conspicuous appearance. The brilliant colours are in this case of a warning nature for the purpose of rendering the animal provided with the stinging cells noticeable and recognisable. But it must be remembered that in a museum jar, or in a laboratory dish, or as an illustration in a book or on the wall, *Dendronotus* is quite as conspicuous and striking an animal as *Eolis*. In order to interpret correctly the effect of their forms and colours, we must see them alive and at home, and we must experiment upon their edibility or otherwise in the tanks of our biological stations.[1]

Let me give you one more example of a somewhat different kind. The soft, unprotected mollusc, *Lamellaria perspicua*, is not uncommonly found associated (as Giard first pointed out) with colonies of the compound Ascidian *Leptoclinum maculatum*, and in these cases the *Lamellaria* is found to be eating the *Leptoclinum*, and lies in a slight cavity which it has excavated in the Ascidian colony, so as to be about flush with the general surface. The integument of the mollusc is, both in general tint and also in surface markings, very like the Ascidian colony with its scattered ascidiozooids. This is clearly a good case of protective colouring. Presumably the *Lamellaria* escapes the observation of its enemies through being mistaken for a part of the *Leptoclinum* colony; and the *Leptoclinum*, being crowded like a sponge with minute sharp-pointed spicules, is, I suppose, avoided as inedible by carnivorous animals, which might devour such things as the soft unprotected mollusc. But the presence of the spicules evidently does not protect the *Leptoclinum* from *Lamellaria*, so that we have, if the above interpretation is correct, the curious result that the *Lamellaria* profits by a protective characteristic of the *Leptoclinum*, for which it has itself no respect, or, to put

[1] See my experiments on Fishes with Nudibranchs in *Trans. Biol. Soc.*, Liverpool, vol. iv. p. 150; and *Nature* for June 26, 1890.

it another way, the *Leptoclinum* is protected against enemies to some extent for the benefit of the *Lamellaria* which preys upon its vitals.

It is, to my mind, no sufficient objection to theories of protective and warning colouration that careful investigation may from time to time reveal cases where a disguise is penetrated, a protection frustrated, an offensive device supposed to confer inedibility apparently ignored. We must bear in mind that the enemies, as well as their prey, are exposed to competition, are subject to natural selection, are undergoing evolution; that the pursuers and the pursued, the eaters and the eaten, have been evolved together; and that it may be of great advantage to be protected from *some*, even if not from all enemies. Just as on land some animals can browse upon thistles whose 'nemo me impune lacessit' spines are supposed to confer immunity from attack, so it is quite in accord with our ideas of evolution by means of natural selection to suppose that some marine animals have evolved an indifference to the noxious sponge or to the bristling Ascidian, which are able by their defensive characteristics, like the thistle, to repel the majority of invaders.

Although we can keep and study the Littoral and Laminarian animals at ease in our zoological stations, it may perhaps be questioned how far we can reproduce in our experimental and observational tanks the conditions of the 'Coralline' and the 'Deep-mud' zones. One might suppose that the pressure—which we have no means as yet for supplying [1]—and which at 30 fathoms amounts to nearly 100 lbs. on the square inch, and at 80 fathoms to about 240 lb., or over 2 cwt. on the square inch, would be an essential factor in the life conditions of the inhabitants of such depths, and yet we have kept half a dozen specimens of *Calocaris macandreæ*, dredged from 70 to 80 fathoms, alive at the Port Erin Biological Station for several weeks; we have had both the red and the yellow forms of *Sarcodictyon catenata*, dredged from 30 to 40 fathoms, in a healthy condition with the polypes freely expanded for an indefinite period; and Mr. Arnold Watson has kept the Polynoid worm, *Panthalis oerstedi*, from the deep mud at over 50 fathoms, alive, healthy, and building its tube under observation, first for a week at the Port Erin Station, and then for many months at Sheffield in a comparatively small tank with no depth of water. Consequently it seems clear that, with ordinary care, almost any marine animals from such depths as are found within the British area may be kept under observation and submitted to experiment in healthy and fairly natural conditions. The Biological Station, with its tanks, is in fact an arrangement whereby we bring a portion of the sea with its rocks and bottom deposits and seaweeds, with its inhabitants and their associates, their food and their enemies, and place it for continuous study on our laboratory table. It enables us to carry on the bionomical investigations to which we look for information as to the methods and progress of evolution; in it lie centred our hopes of a comparative physiology of the invertebrates—a physiology not wholly medical—and finally to the Biological Station we confidently look for help in connection with our coast fisheries. This brings me to the last subject which I shall touch upon, a subject closely related both to Oceanography and Bionomics, and one which depends much for its future advance upon our Biological Stations—that is the subject of

Aquiculture,

or industrial Ichthyology, the scientific treatment of fishery investigations, a subject to which Professor M'Intosh has first in this country directed the attention of zoologists, and in which he has been guiding us for the last decade by his admirable researches. What chemistry is to the aniline, the alkali, and some other manufactures, marine zoology is to our fishing industries.

[1] Following up M. Regnard's experiments, some mechanical arrangement whereby water could be kept circulating and aërated under pressure in closed tanks might be devised, and ought to be tried at some zoological station. I learn from the Director at the Plymouth Station that some of the animals from deep water, such as Polyzoa, do not expand in their tanks.

Although zoology has never appealed to popular estimation as a directly useful science having industrial applications in the same way that Chemistry and Physics have done, and consequently has never had its claims as a subject of technical education sufficiently recognised; still, as we in this Section are well aware, our subject has many technical applications to the arts and industries. Biological principles dominate medicine and surgery. Bacteriology, brewing, and many allied subjects are based upon the study of microscopic organisms. Economic entomology is making its value felt in agriculture. Along all these and other lines there is a great future opening up before biology, a future of extended usefulness, of popular appreciation, and of value to the nation—and not the least important of these technical applications will, I am convinced, be that of zoology to our fishing industries. When we consider their enormous annual value—about eight millions sterling at first hand to the fisherman, and a great deal more than that by the time the products reach the British public, when we remember the very large proportion of our population who make their living directly or indirectly (as boatbuilders, net-makers, &c.) from the fisheries, and the still larger proportion who depend for an important element in their food supply upon these industries; when we think of what we pay other countries—France, Holland, Norway—for oysters, mussels, lobsters, &c., which we could rear in this country if our sea-shores and our sea-bottom were properly cultivated; and when we remember that fishery cultivation or aquiculture is applied zoology, we can readily realise the enormous value to the nation which this direct application of our science will one day have—perhaps I ought rather to say, we can *scarcely* realise the extent to which zoology may be made the guiding science of a great national industry. The flourishing shell-fish industries of France, the oyster culture at Arcachon and Marennes, and the mussel culture by bouchots in the Bay of Aiguillon, show what can be done as the result of encouragement and wise assistance from Government, with constant industry on the part of the people, directed by scientific knowledge. In another direction the successful hatching of large numbers (hundreds of millions) of cod and plaice by Captain Dannevig in Norway, and by the Scottish Fishery Board at Dunbar, opens up possibilities of immense practical value in the way of restocking our exhausted bays and fishing banks—depleted by the over-trawling of the last few decades.

The demand for the produce of our seas is very great, and would probably pay well for an increased supply. Our choicer fish and shellfish are becoming rarer, and the market prices are rising. The great majority of our oysters are imported from France, Holland, and America. Even in mussels we are far from being able to meet the demand. In Scotland alone the long line fishermen use nearly a hundred millions of mussels to bait their hooks every time all the lines are set, and they have to import annually many tons of these mussels at a cost of from 3*l.* to 3*l.* 10*s.* a ton. If 'squid' (cuttlefish) could be obtained in sufficient quantity, it would probably be even more valuable than mussels as bait, but its price is usually prohibitive. I happen to know that a fishing firm in Aberdeen paid during this last winter over 200*l.* for squid bait for a single boat's lines for the three months October to December, and there are fifty to sixty of such boats north of the Tyne. Here is a nice little industry ready for anyone who can capture or cultivate the common squid in quantity.

Whether the wholesale introduction of the French method of mussel culture, by means of bouchots, on to our shores would be a financial success is doubtful. Material and labour are dearer here, and beds, scars, or scalps seem, on the whole, better fitted to our local conditions; but as innumerable young mussels all round our coasts perish miserably every year for want of suitable objects to attach to, there can be no reasonable doubt that the judicious erection of simple stakes or plain bouchots would serve a useful purpose, at any rate in the collection of seed, even if the further rearing be carried on by means of the bed system.

All such aquicultural processes require, however, in addition to the scientific knowledge, sufficient capital. They cannot be successfully carried out on a small scale. When the zoologist has once shown as a laboratory experiment, in the zoological station, that a particular thing can be done—that this fish can be hatched or that shellfish can be reared under certain conditions which promise to be an industrial success, then the matter should be carried out by the Government [1] or by capitalists on a sufficiently large scale to remove the risk of results being vitiated by temporary accident or local variation in the conditions. It is contrary, however, to our English traditions for Government to help in such a matter, and if our local Sea-Fisheries Committees have not the necessary powers nor the available funds, there remains a splendid opportunity for opulent landowners to erect sea-fish hatcheries on the shores of their estates, and for the rich merchants of our great cities to establish aquiculture in their neighbouring estuaries, and by so doing instruct the fishing populations, resuscitate the declining industries, and cultivate the barren shores—in all reasonable probability to their own ultimate profit.

In addition to the farming of our shores there is a great deal to be done in promoting the fishing industries on the inshore and offshore grounds along our coast, and in connection with such work the first necessity is a thorough scientific exploration of our British seas by means of a completely equipped dredging and trawling expedition. Such exploration can only be done in little bits, spasmodically, by private enterprise. From the time of Edward Forbes it has been the delight of British marine zoologists to explore, by means of dredging from yachts or hired vessels during their holidays, whatever areas of the neighbouring seas were open to them. Some of the greatest names in the roll of our zoologists, and some of the most creditable work in British zoology, will always be associated with dredging expeditions. Forbes, Wyville Thomson, Carpenter, Gwyn Jeffreys, M'Intosh, and Norman—one can scarcely think of them without recalling—

> 'Hurrah for the dredge, with its iron edge,
> And its mystical triangle,
> And its hided net, with meshes set,
> Odd fishes to entangle!' [2]

Much good pioneer work in exploration has been done in the past by these and other naturalists, and much is now being done locally by committees or associations—by the Dublin Royal Society on the West of Ireland, by the Marine Biological Association at Plymouth, by the Fishery Board in Scotland, and by the Liverpool Marine Biology Committee in the Irish Sea; but few zoologists or zoological committees have the means, the opportunity, the time to devote—along with their professional duties—to that detailed systematic survey of our whole British sea-area which is really required. Those who have not had experience of it can scarcely realise how much time, energy, and money it requires to keep up a series of dredging expeditions, how many delays, disappointments, expensive accidents and real hardships there are, and how often the naturalist is tempted to leave unprofitable ground, which ought to be carefully worked over, for some more favoured spot where he knows he can count upon good spoil. And yet it is very necessary that the whole ground—good or bad though it may be from the zoological point of view—should be thoroughly surveyed, physically and biologically, in order that we may know the conditions of existence which environ our fishes, on their feeding grounds, their spawning grounds, their 'nurseries,' or wherever they may be.

The British Government has done a noble piece of work which will redound to its everlasting credit in providing for, and carrying out, the 'Challenger' expedition. Now that that great enterprise is completed, and that the whole scientific world is united in appreciation of the results obtained, it would be a glorious consequence, and surely a very wise action in the interests of the national fisheries, for the Government to fit out an expedition, in charge of two or three zoologists and fish-

[1] We require in England a Central Board or Government Department of Fisheries, composed in part of scientific experts, and that not merely for the purpose of imposing and enforcing regulations, but still more, in order that research into Fisheries problems may be instituted and aquicultural experiments carried out.

[2] The dredging song (see *Memoir of Edward Forbes*, p. 247).

eries experts, to spend a couple of years in exploring more systematically than has yet been done, or can otherwise be done, our British coasts from the Laminarian zone down to the deep mud. No one could be better fitted to organise and direct such an expedition than Dr. John Murray.

Such a detailed survey of the bottom and of the surface waters, of their condition and their contents, at all times of the year for a couple of years, would give us the kind of information we require for the solution of some of the more difficult fishery problems—such as, the extent and causes of the wanderings of our fishes, which 'nurseries' are supplied by particular spawning grounds, the reason of the sudden disappearance of a fish such as the haddock from a locality, and in general the history of our food fishes throughout the year. It is creditable to our Government to have done the pioneer work in exploring the great oceans, but surely it would be at least equally creditable to them—and perhaps more directly and immediately profitable, if they look for some such return from scientific work—to explore our own seas and our own sea-fisheries.

There is still another subject connected with the fisheries which the biologist can do much to elucidate—I mean the diseases of edible animals and the effect upon man of the various diseased conditions. It is well known that the consumption of mussels taken from stagnant or impure water is sometimes followed by severe symptoms of irritant poisoning which may result in rapid death. This 'musselling' is due to the presence of an organic alkaloid or ptomaine, in the liver of the mollusc, formed doubtless by a micro-organism in the impure water. It is clearly of the greatest importance to determine accurately under what conditions the mussel can become infected by the micro-organism, in what stage it is injurious to man, and whether, as is supposed, steeping in pure water with or without the addition of carbonate of soda will render poisonous mussels fit for food.

During this last year there has been an outcry, almost amounting to a scare, and seriously affecting the market,[1] as to the supposed connection between oysters taken from contaminated water and typhoid fever. This, like the musselling, is clearly a case for scientific investigation, and, with my colleague Professor Boyce, I have commenced a series of experiments and observations, partly at the Port Erin Biological Station, where we have oysters laid down on different parts of the shore under very different conditions, as well as in dishes and tanks, and partly at University College, Liverpool.

Our object is to determine the effect of various conditions of water and bottom upon the life and health of the oyster, the effect of the addition of various impurities to the water, the conditions under which the oyster becomes infected with the typhoid Bacillus, and the resulting effect upon the oyster, the period during which the oyster remains infectious, and lastly, whether any simple practicable measures can be taken (1) to determine whether an oyster is infected with typhoid, and (2) to render such an oyster innocuous to man. As Professor Boyce and I propose to lay a paper upon this subject before the Section, I shall not occupy further time now by a statement of our methods and results.

I have probably already sufficiently indicated to you the extent and importance of the applications of our science to practical questions connected with our fishing industries. But if the zoologist has great opportunities for usefulness, he ought always to bear in mind that he has also grave responsibilities in connection with Fisheries investigations. Much depends upon the results of his work. Private enterprise, public opinion, local regulations, and even imperial legislation may all be affected by his decisions. He ought not lightly to come to conclusions upon weighty matters. I am convinced that of all the varied lines of research in modern zoology, none contains problems more interesting and intricate than those of Bionomics, Oceanography, and the Fisheries, and of these three series the problems connected with our Fisheries are certainly not the least interesting, not the least intricate, and not the least important in their bearing upon the welfare of mankind.

[1] I am told that between December and March the oyster trade decreased 75 per cent.

Appendix.

List of Species taken in one haul, on June 23, 1895 (see p. 705).

SPONGES:
- *Reniera*, sp.
- *Halichondria*, sp.
- *Cliona celata*
- *Suberites domuncula*
- *Chalina oculata*

COELENTERATA:
- *Dicoryne conferta*
- *Halecium halecinum*
- *Sertularia abietina*
- *Coppinia arcta*
- *Hydrallmania falcata*
- *Campanularia verticillata*
- *Lafoëa dumosa*
- *Antennularia ramosa*
- *Alcyonium digitatum*
- *Virgularia mirabilis*
- *Sarcodictyon catenata*
- *Sagartia*, sp.
- *Adamsia palliata*

ECHINODERMATA:
- *Cucumaria*, sp.
- *Thyone fusus*
- *Asterias rubens*
- *Solaster papposus*
- *Stichaster roseus*
- *Porania pulvillus*
- *Palmipes placenta*
- *Ophiocoma nigra*
- *Ophiothrix fragilis*
- *Amphiura chiajii*
- *Ophioglypha ciliata*
- *O. albida*
- *Echinus sphæra*
- *Spatangus purpureus*
- *Echinocardium cordatum*
- *Brissopsis lyrifera*
- *Echinocyamus pusillus*

VERMES:
- *Nemertes neesii*
- *Chætopterus*, sp.
- *Spirorbis*, sp.
- *Serpula*, sp.
- *Sabella*, sp.
- *Owenia filiformis*
- *Aphrodite aculeata*
- *Polynoë*, sp.

CRUSTACEA:
- *Scalpellum vulgare*
- *Balanus*, sp.
- *Cyclopicera nigripes*
- *Acontiophorus elongatus*
- *Artotrogus magniceps*
- *Dyspontius striatus*
- *Zaus goodsiri*
- *Laophonte thoracica*
- *Stenhelia reflexa*
- *Lichomolgus forficula*
- *Anonyx*, sp.
- *Galathea intermedia*
- *Munida bamffica*
- *Crangon spinosus*
- *Stenorhynchus rostratus*
- *Inachus dorsettensis*
- *Hyas coarctatus*
- *Xantho tuberculatus*
- *Portunus pusillus*
- *Eupagurus bernhardus*
- *E. prideauxii*
- *E. cuanensis*
- *Eurynome aspera*
- *Ebalia tuberosa*

POLYZOA:
- *Pedicellina cernua*
- *Tubulipora*, sp.
- *Crisia cornuta*
- *Cellepora pumicosa*, and three or four undetermined species of Lepralids
- *Flustra securifrons*
- *Scrupocellaria reptans*
- *Cellularia fistulosa*

MOLLUSCA:
- *Anomia ephippium*
- *Ostrea edulis*
- *Pecten maximus*
- *P. opercularis*
- *P. tigrinus*
- *P. pusio*
- *Mytilus modiolus*
- *Nucula nucleus*
- *Cardium echinatum*
- *Lissocardium norvegicum*
- *Cyprina islandica*
- *Solen pellucidus*
- *Venus gallina*
- *Lyonsia norvegica*
- *Scrobicularia prismatica*
- *Astarte sulcata*
- *Modiolaria marmorata*
- *Saxicava rugosa*
- *Chiton*, sp.
- *Dentalium entale*
- *Emarginula fissura*
- *Velutina lævigata*
- *Turritella terebra*
- *Natica alderi*
- *Fusus antiquus*
- *Aporrhais pespelicani*
- *Oscanius membranaceus*
- *Doris*, sp.
- *Eolis coronata*
- *Tritonia plebeia*

TUNICATA:
- *Ascidiella virginea*
- *Styelopsis grossularia*
- *Eugyra glutinans*
- *Botryllus*, sp.
- *B.*, sp.

The following Reports and Papers were read:—

1. *Third Report on the Marine Zoology, Botany, and Geology of the Irish Sea.*—See Reports, p. 455.

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2. *Interim Report on the Migration of Birds.*—See Reports, p. 473.

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3. *Fifth Report on the Zoology of the Sandwich Islands.* See Reports, p. 467.

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4. *Report on the Occupation of a Table at the Zoological Station at Naples.* See Reports, p. 474.

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5. *Report on Investigations made at the Laboratory of the Marine Biological Association at Plymouth.*—See Reports, p. 469.

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6. *Report on the Investigation of the Zoology and Botany of the West India Islands.*—See Reports, p. 472.

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7. *Report on the Compilation of an Index Generum et Specierum Animalium.*—See Reports, p. 473.

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8. *Report on Physiological Applications of the Phonograph.* See Reports, p. 454.

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9. *Some Remarks on the Stereornithes, a Group of extinct Birds from South America.* By C. W. ANDREWS.

A brief history of the discovery of these remarkable birds is given, together with a short account of the more important opinions that have been expressed concerning their affinities.

The structure of the skeleton of Phororhacos, recently described by Ameghino, is considered, and, after comparison with certain other birds, some suggestions are made as to the probable affinities of the genus. Phororhacos is regarded as a true carinate bird, in which, as in the dodo, aphanapteryx, and many others, the wings have undergone reduction through disuse. It seems to have been a highly specialised form, and probably has left no direct descendants: its nearest relatives may perhaps be found among the Gruiformes, especially in the Psophiidæ and Dicholophi, and it possibly represents a specialised offshoot from the generalised stock which gave rise to these forms. No special affinities with the living Ratitæ are found, and it appears very doubtful whether Gastornis is any way related.

The other genera described by Ameghino are much less completely known; some of them, however, differ so considerably from Phororhacos, and in several cases from one another, that they should probably be referred to several distinct families, as, indeed, has already been done by Moreno and Mercerat. The Stereornithes, therefore, appear to include a somewhat heterogeneous group of birds, whose chief points of resemblance seem to lie in their large size and more or less reduced power of flight. The unfortunate absence of specimens of these interesting fossils from the European museums renders any detailed comparison with existing forms impossible, so that the opinions expressed in the present paper must be regarded as provisional only.

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10. *Some Facts and Reflections drawn from a Study of Budding in Compound Ascidians. By* Professor W. E. RITTER (*University of California*).

Numerous recent writers have doubted the genetic unity of the compound ascidians; *i.e.*, they have doubted whether their property of budding, the character which all agree to be the final test of whether an ascidian is simple or compound, has not been acquired more than once. Of these authors I may mention Lacaze-Duthiers, E. van Beneden, Herdman, Seeliger, Lahille, and Sluiter.

In discussing the subject van Beneden has made the apt remark that no zoologist would think of uniting all bud-producing actinians in one group and placing them over against all others that do not reproduce in this manner. In his well-known report on the compound ascidians of the 'Challenger' Expedition, Professor Herdman not only reached the conclusion that the group is polyphyletic in origin, but he also marshalled his broad knowledge to show that they probably originated at three distinct points from the simple ascidians, and to show also what genera trace their origin back to each of these three starting-points. The author regarded this as one of the most important generalisations reached by his study of the great 'Challenger' collection.

Quite recently M. Lahille has proposed an entirely new classification of the Tunicata, in which he ignores budding as a diagnostic character of at most greater than generic importance. That, however, this writer has treated the matter too lightly, whether regarded from a morphological or a physiological point of view, will, I apprehend, be allowed by most students of the group.

It is not my purpose to discuss here a classification of the compound ascidians based on the hypothesis of their polyphyletic origin, but rather to show, first, that they have had such an origin, and, secondly, to consider certain developmental probabilities that are involved in, or, rather, are the necessary results of, such an hypothesis.

In the interest of brevity and clearness my discussion will aim almost entirely at showing that two genera of compound ascidians are, structurally considered, considerably more unlike each other than each is unlike a genus of simple ascidians which, in turn, are widely separated from each other.

The genera to which I refer are *Perophora* and *Goodsiria* as representatives of the compound ascidians, and *Ascidia* and *Polycarpa* as representing the simple ascidians.

Definitely stated the proposition to be established is this: *Perophora* and *Goodsiria* are less closely related to each other than on the one hand *Perophora* is to *Ascidia*, and on the other *Goodsiria* is to *Polycarpa*.

We will first compare the several genera anatomically, and afterwards the budding in *Perophora* and *Goodsiria;* and we may begin with *Polycarpa* and *Goodsiria*. *Polycarpa* is closely related to *Cynthia*, and still more closely to *Styela*. The genus is, however, distinctly separated from *Cynthia*, particularly by its possessing simple tentacles and sexual organs in the form of so-called polycarps.

Goodsiria belongs to the Polystyelidæ, a small family of compound ascidians, founded by Professor Herdman for the reception of several genera that are, as our knowledge now stands, closely related to one another, and well separated from all other compound ascidians, although they certainly have rather close affinities with the Botryllidæ.

The close similarity in structure between *Polycarpa* and the Polystyelidæ has been recognised by nearly all investigators who have studied them, and my own work has, I think, shown their kinship to be even closer than has heretofore been supposed. In fact, the resemblance is so close between an undescribed species of

Polycarpa which I have found on our Californian coast and *Goodsiria dura* from the same locality that I am sure no zoologist would ever think of recognising more than a specific difference between them, did not the one reproduce by budding while the other does not. Two points, however, must be briefly dwelt upon—one of resemblance, the other of difference.

It is well known that the hypophyseal duct in ascidians is usually situated on the ventral side of the ganglion; but it is also well known that *Botryllus* forms an exception to this rule, for in this species the duct is *dorsal* to the *ganglion.* I find that *Goodsiria* agrees with *Botryllus* in this peculiarity. I also find that the only species of *Polycarpa* which I have examined with reference to the point, viz., *Polycarpa pomaria,* possesses the same unusual character. In some cases, at least, it is well nigh, if not wholly, impossible to ascertain the relation of the duct to the ganglion without the aid of sections. It appears to me, consequently, that the occurrence of this very exceptional condition in both *Polycarpa* and *Goodsiria,* when considered together with their many other close resemblances, adds considerable weight to the belief in their close kinship.

The difference to which I refer is the presence usually of well-marked folds in the branchial sac of *Polycarpa* and the rudimentary condition or entire absence of these folds in *Goodsiria.* In the sac of *Goodsiria dura* there is no trace of folds proper, but two of the five internal longitudinal vessels on each side of the sac are distinctly nearer together than are the others. A similar approximation of these vessels where no true folds exist occurs in numerous species of ascidians, and Herdman has given good reasons for regarding it as evidence of folds that have been lost. The vessels are usually crowded on the folds more than elsewhere; the folds in some cases disappear, but the crowded vessels, being a deeper morphological character, persist though on a plain surface. Now it can be shown that in genera where these folds are present as a rule, but where they may be rudimentary or absent, it is, in a general way, in the larger species that they are best developed, and in the smaller ones that they are rudimentary or absent. From this fact and others I *am disposed to look upon* Goodsiria *as a pigmy* Polycarpa.

Next, concerning the structural likenesses between *Ascidia* and *Perophora,* they are close in most points and not remote in any. Perhaps the most important difference is found in the branchial sacs, but this difference is interesting. *Ascidia* has internal longitudinal vessels which are papillated, while *Perophora* has no internal longitudinal vessels; but it does have long interserial papillæ, each of which is provided with two processes of variable length, one directed anteriorly, the other posteriorly. Now if these processes on one series of the papillæ were to reach across and unite with the corresponding ones of an adjacent series of papillæ, internal papillated longitudinal vessels would be produced entirely similar to those existing in *Ascidia.* Suggestively enough, individuals of at least two species of *Perophora* have been observed in which just such a union does exist. From this it would appear that the lateral processes of the papillæ in *Perophora* are remnants of internal longitudinal vessels; and this fact, taken in connection with others, inclines me *to regard* Perophora *as a pigmy* Ascidia, *just as we have seen that* Goodsiria *may be regarded as a pigmy* Polycarpa.

In comparing *Goodsiria* and *Perophora* on the one hand and *Polycarpa* and *Ascidia* on the other, we find a marked contrast in each case in nearly every organ of the body.

Turning to reproduction by gemmation, the buds of *Perophora* are produced by a proliferous stolon, while those of *Goodsiria* are formed directly from the body of the parent zooids, the inner layer of the bud being an evagination of the parietal wall of the peribranchial sac. Are these two methods of origin of buds reducible to a common type? I may say at once that a conclusive answer to this query is not yet possible, for the reason that we do not know how the first bud, *i.e.,* the bud from the *embryozooid,* arises in either genus.

I cannot leave this part of the subject without saying a single word about the epicardium, a structure that is certainly of much importance in connection with the budding of many compound ascidians. The only structures in *Goodsiria* that could possibly be called by this name are two broad, shallow pouches at the posterior end of the peribranchial sacs, one for each side. They certainly have nothing whatever to do with the budding, since the buds arise about as far away from them as the size of the ascidiozooids will permit. Furthermore, they do not have the same relations as the epicardium of *Clavelina* and other ascidians. In *Goodsiria* and *Botryllus*, I may add, they are *merely parts* of the peribranchial sacs; while in other cases they arise in a definite way from the branchial sac.

In my opinion it is an unjustifiable and purposeless forcing of things to attempt to see anything in either *Goodsiria* or *Botryllus* that is homologous with the epicardium of *Clavelina* and other budding ascidians.

Relying chiefly on the evidence from adult structure, we are, then, as it seems to me, obliged to conclude that the compound ascidians have arisen from the simple ones by at least two distinct groups of these latter having independently acquired the property of reproduction by budding. Now, since the *processes* of evolution are of quite as much scientific interest to us as are its *products*, we can hardly avoid an attempt to gain some insight into the developmental processes that have been in operation in this instance.

One question we are impelled to ask is whether some cause for the origin of budding in these animals may not be detected here, where it, whatever it is, has been so potent as to produce its effect twice. A possible cause does suggest itself, and I venture to present it to you very briefly. I confess, however, that the venture is made not without some trepidation.

It will be remembered that we have given reasons for regarding *Goodsiria* and *Perophora* as simplified or pigmy Polycarpæ and Ascidiæ respectively. It seems to me possible that budding might have arisen in these genera of simple ascidians as a result of the diminution in size and simplification in structure of some of the species; and I am disposed to regard the diminution in size as the most important factor. It appears to me that the smallest species of *Polycarpa*, for example, have a much poorer chance of survival than do the larger and largest ones, owing to the simple circumstance that they cannot produce anything like so large a number of embryos as do the larger species. The smallest species that I know of this genus is only 3 or 4 millimetres in length, while most of the species reach some centimetres at least in length; and it is a matter of common observation that in the ascidians the size of the ovary and the number of the ova are in direct proportion to the size of the parent individuals. It is certain that the total volume of the sexual products of a large *Polycarpa* would be many times greater than the entire animal of the small species to which I have just referred; and the ova in the one case are not much, if at all, larger in the one than in the other. The suggestion is *that in these cases budding has in some way arisen as a compensation for the diminished power of sexual reproduction.*

A developmental question of wider moment than the one just disposed of, and one which I discuss with much greater confidence, is this. If blastogenesis has had two or more wholly independent origins among ascidians, how is the close similarity in the development of the blastozooids of the whole group to be explained? The interest of this question is greatly increased by the fact that not only is the development of the blastozooids much alike in all the species, but also that this development is quite unique as compared with the development of the embryozooid.

In contrasting the development from an embryo and from a bud it is seen that in *embryonic development the ectoderm produces the matrix of the test, the peribranchial sacs, and the central nervous system and hypophysial duct,* while in the bud we see these four parts of the animal produced by the inner or so-called endodermic vesicle.

Concerning the endodermic, or rather inner vesicle origin of the ganglion and hypophysial duct, I speak with perfect confidence as regards *Goodsiria* and *Perophora*, for this confidence rests on my own observations. The case for the *Goodsiria* bud in particular is as clear as anyone could wish a developmental fact to be.

Enough of the facts are now before us to enable us to state the problem clearly. If the property of budding has been independently acquired by two quite widely separated groups of simple ascidians, how has it come about that the development of the blastozooids agrees so closely, and in such remarkable peculiarities, as the origin of the nervous system, and the peribranchial sac from the *outer layer* of the *embryo* and from the *inner layer* of the *bud?*

I believe the answer to be that we have before us an excellent case of developmental opportunism. The inner layer of the bud gives origin to nearly all the organs of the blastozooid because physiological influences working to such a course of development have been stronger than the hereditary influences tending to make the development follow the embryonic method.

The case is particularly interesting because, as I believe, we are able to put our finger on the physiological cause that has been so potent in modifying the *direction*, not the *final result* of the mighty force of heredity.

You will remember that the outer layer of the embryo produces the matrix of the test, the nervous system, and the peribranchial sacs. Now observe. The production of the two last-mentioned structures is a *purely developmental matter*. It concerns the embryonic period only. The organs become separated, or practically so, from their source during this period, and the outer layer has nothing more to do with them, at least functionally. Not so with the production of the test. This is not merely an *embryonic matter;* it is an *enduring physiological matter*. The test must be constantly renewed throughout the life of the individual. The outer layer is consequently an active secretory *organ* from an early embryonal period to the end of the animal's life; and since the outer layer of the bud is merely a portion of the outer layer of the parent or of the stolon, as the case may be, it is at no time an *embryonic layer;* it is, from the very beginning, a *differentiated organ*. It has to grow, to be sure; but in addition it has a well-established and important physiological function to perform. Very different is it with the inner layer. Its cells are strictly undifferentiated—embryonic, if you will. They do not even have to digest their own food, for they are constantly bathed in the maternal blood. The layer does not come in contact with the external world at any time or at any point. It has nothing to do but to develop. Why should it not relieve the outer layer from producing some of the parts that it produces in the embryo? And it does.

I must hasten to say that this physiological explanation of the peculiarities of ascidian bud development was suggested by Seeliger, though he did not make as much of it as I believe it deserves.

There are several other instances among budding animals where I am inclined to think that assignable functional influences have more or less radically changed the method of development, but time prevents reference to more than one of these. Chun has very recently shown that in *Rathkea octopunctata*, one of the Medusæ, the inner layer of the parent takes no part whatever in the formation of the bud. The buds are produced on the wall of the stomach, and it appears to me highly probable that the ectoderm alone shares in the process, because the endoderm is so completely given over to the digestive function, while the ectoderm cells have much more largely retained their undifferentiated condition owing to their being in great measure protected from the external world by the subumbrella.

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11. *Outlines of a new Classification of the Tunicata.*
By WALTER GARSTANG, *M.A., F.Z.S., Fellow of Lincoln College, Oxford.*

Professor Herdman's classification of the Tunicata is based very largely upon modifications of external form connected with gemmation and the formation of colonies. It involves, as Professor Herdman himself admits, an unnatural separation of forms admittedly allied, *e.g.*, *Pyrosoma* and *Doliolum*, *Clavelina* and the Distomidæ, *Diazona* and *Ciona*, as well as to an unnatural approximation of forms whose structure is altogether dissimilar, *e.g.*, *Pyrosoma* and *Cœlocormus*, *Perophora* and *Clavelina*.

Lahille has promulgated a system based upon modifications of the structure of the pharynx. His arrangement of the fixed ascidians seems to me admirable, but his treatment of the pelagic forms is most unsatisfactory. He follows Herdman in placing *Pyrosoma* near *Cœlocormus* and the Didemnidæ, though upon different and purely speculative grounds. *Salpa* is divorced from *Doliolum* through an erroneous interpretation of the ciliated pits on the gill of *Salpa*.

The subjoined scheme is based upon anatomical and embryological facts. The pelagic caducichordate types possess a single row of undivided branchial slits (protostigmata). This condition is recapitulated, as I have elsewhere shown, in the ontogeny of various fixed ascidians, but the protostigmata of the young post-larval form are subsequently subdivided into rows of minute secondary stigmata. The structure of *Pyrosoma* and its allies is thus more primitive than that of any of the fixed ascidians.

The two groups, Thaliacea and Ascidiacea, are distinguished in my scheme upon this basis. My subdivision of the Thaliacea explains itself; that of the Ascidiacea I have adopted, with some modifications, from Lahille.

TUNICATA.

PERENNICHORDATA.

I. *Endostylophora.*—Pharynx provided with an endostyle. E.g., *Oikopleura, Fritillaria.*

II. *Polystylophora.*—Endostyle absent; pharynx provided with numerous finger-like processes arranged in rows. E.g., *Kowalevskia.*

CADUCICHORDATA.

I. *Thaliacea.*—Protostigmata undivided; cloaca posterior. Pelagic.

- i. Myosomata.—Musculature in bands; pharynx without internal longitudinal bars; axis of row of protostigmata oblique or transverse; lateral atria small. E.g., *Doliolum, Salpa, Anchinia.*
- ii. Pyrosomata.—Musculature diffuse; pharynx with internal longitudinal bars; axis of row of protostigmata longitudinal; lateral atria coextensive with pharynx. E.g., *Pyrosoma.*

II. *Ascidiacea.*—Protostigmata subdivided into rows of secondary stigmata; cloaca dorsal. Fixed.

- i. Stolidobranchia.—Pharynx with internal longitudinal bars; bars solid and ribbon-shaped. E.g., *Botryllus, Cynthia, Goodsirea.*
- ii. Phlebobranchia.—Pharynx with internal longitudinal bars; bars tubular and vascular. E.g., *Perophora, Ascidia, Diazona.*
- iii. Aplousobranchia.—Pharynx without internal longitudinal bars; horizontal membranes present. E.g., *Clavelina, Distaplia, Amaræcium, Didemnum.*

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12. *On the Presence of Skeletal Elements between the Mandibular and Hyoid Arches of* Hexacanthus *and* Læmargus. *By* Dr. PHILIP WHITE.

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13. *On the Presence of a Sternum in* Hexanchus griseus. *By* Dr. PHILIP WHITE.

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14. *On the Creodonta. By* Professor W. B. SCOTT.

Our knowledge of this remarkable group of extinct flesh eaters has been of slow growth, and only lately has sufficiently perfect material been recovered to give us an accurate insight into the structure and relationships of several of the more important genera.

The creodonts are almost exclusively Eocene forms, and especially characterise the Lower Eocene, the Wasatch being probably their time of culmination, while only one genus (*Hyænodon*) is known to pass into the Miocene. The appearance of five distinctly differentiated families in the Puerco indicates that their origin is to be looked for in the Cretaceous formation. North America was eminently the home of the group, having many more genera and families than Europe has yet yielded. So far, none are known from the southern hemisphere.

Though including several divergent lines of differentiation, the group is characterised by a fairly uniform structure. The incisors and canines are of the carnivorous type, and rarely are reduced in number; the sectorials are either absent or present in more than one pair (except in the *Miacidæ*); the molars generally retain the tritubercular plan more or less distinctly. The milk dentition is of the same character as in the true carnivora. The brain is small and the hemispheres usually little convoluted. The skull has a very long slender cranial part, with deep postorbital constriction, very prominent sagittal and occipital crests, and a short facial region. The vertebræ are remarkable for the complex zygapophyses on the lumbars and posterior thoracics. The limbs are relatively short and light, the humerus retaining the epicondylar foramen, and the femur the third trochanter. The feet are weak and almost invariably plantigrade and pentadactyl, and with only one known exception, the scaphoid, lunar, and central remain separate. The ungual phalanges are very generally cleft at the tip, as in the insectivora.

The creodonts fall quite naturally into two sections, one with more or less blunt and tuberculated teeth, and the other with trenchant teeth. The first section, which includes three families, the Arctocyonidæ, Triisodontidæ and Mesonychidæ, is most abundant in the Puerco, and has but a single representative in the Middle and Upper Eocene. No existing forms appear to have been derived from the creodonts with tuberculate teeth.

The second section includes five families, the Proviverridæ, Oxyænidæ, Hyænodontidæ, Palæonictidæ, and Miacidæ, the last of which is very sharply distinguished from all other creodonts, and forms the connecting link with the true carnivora. The creodonts with trenchant teeth are most important and highly developed in the Wasatch and Bridger, after which they decline, their place being gradually taken by the carnivores.

Most of the fissipede carnivora would seem to be clearly derivable from the *Miacidæ*, except the cats, the origin of which is still obscure, and which are remarkable for the extremely rapid specialisation which they attain at a very early period. The Pinnipedia, on the other hand, would seem to have been derived from some other creodont family. Wortman has suggested, with considerable probability, that the *Oxyænidæ* were the ancestors of the Pinnipedes, but the gap between the two is yet so great as to render this uncertain.

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *On some Results of Scientific Investigation as applied to Fisheries. By* Professor W. C. M'Intosh, *F.R.S.*

My remarks are based on experience mainly, but not altogether, gained in Scotland, but are applicable to the empire, or indeed to European fisheries. The greater responsibility has been felt, since England possesses no public department precisely corresponding to the Fishery Board for Scotland. It may be pointed out that such investigations in regard to the fisheries are of so recent a date that perhaps it is too early to estimate comprehensively the results; but since there are hostile critics it may be well to take a general survey of the results—often gained under considerable difficulty, especially in regard to sea-going ships, for only a small steam vessel has been at the service of the Fishery Board, instead of a powerful vessel capable of going to distant grounds in rough weather. Previous to 1883 no statistics of a reliable kind, other than those of herrings and salted fishes, were available to guide the Legislature as to whether marine fisheries were diminishing, stationary, or increasing. This anomalous state of things permitted indulgence in exaggerated statements as to the scarcity of fishes, and the decline, or, as it was said, impending ruin of the fisheries. While thus a very great improvement had been made, the returns were far from being complete. They give the greater part of the fishes caught, but left many unreported. If anything is national property it is the sea, and it ought to be comparatively an easy task to give an account of its stewardship.

In the scientific report to the Royal Commission of 1884 the closing of certain bays against beam and otter trawling was indicated thus:—'The experiment of allowing a bay having a definite boundary and suitable for observation to remain unfished for several years either by line, trawl, or stake-net would perhaps be more satisfactory' (than a close time). 'Its fish fauna would be carefully examined at closure, and frequently during the period, and the general increase in size, emigration, and immigration of the fishes noted. Advantage might be taken at the same time to increase the number of its valuable food-fishes, *e.g.*, turbot and soles, by artificial means. Such an experiment would give a valuable basis for future legislation, tend to increase our knowledge of the food-fishes in a remarkable degree, and would be worthy of the interests which this country has in the department of sea fisheries.' It was afterwards arranged to leave out the line fishermen, since many of the older men with small boats would have suffered hardship; and, after some years' observations, the Fishery Board decided to close all the water within the three-mile limit, besides certain larger areas. These closures were made, rightly or wrongly, on the faith of the scientific experiments made by the Board. The investigations also showed from 1884 onwards that the three-mile limit was insufficient to protect the spawning fishes, which, as a rule, were beyond that area. Investigation has also cleared up the migrations of fishes. In shallow bays ripe plaice are seldom found, almost all occurring in the deeper water beyond the three-mile limit. Yet the number of young plaice in such areas is prodigious, the eggs and young being wafted into the shallower water. There they grow till they reach a size of 10 to 13 inches, when they seek the outer waters, in which to attain maturity and to grow to full size. This explains the occurrence of the enormous number of these fishes in so limited an area, as, for instance, in St. Andrews Bay, and their survival after the use of the most extensive and persistent means of capture. Similarly, while the cod spawns are in the off-shore waters, the very young forms, ranging from $\frac{3}{4}$ in. to an inch, appear in the in-shoré grounds in June, haunt the borders of the tidal rocks for some time, and again return to breed in deep water. On the other hand, the very young haddock is an off-shore fish; and so is the very young ling, the latter, when from three to seven inches, migrating shorewards and returning to deep water for adult life. Scientific investigation has shown the enormous fecundity of food-fishes, as well as the provision by which only a portion of the roe ripens at a given time. With wise regulations, therefore, our waters might always be relied on for supplies. We have largely increased our knowledge of the sizes of the respective sexes of marine fishes at maturity, and the development of the eggs in the roe, and their numerical proportion to each other. In this work no one had done more valuable service than Dr. Fulton, the Scientific Superintendent of the Fishery Board for Scotland, and the subject has been further elucidated by Mr. J. T. Cunningham, Mr. Calderwood, and Mr. Holt. Such knowledge in regard to Scotland made it clear that the legislative proposal of a size-limit of 10 or 12 inches—below which fishes were to be unsaleable—would be no protection, for instance, to a ripe plaice, though it might tend to preserve the species till it reached somewhat deeper waters. No feature, again, has been more prominently brought out by scientific investigation than the fact that the eggs of almost all our food-fishes float, or are pelagic. Their wide distribution is thus provided for, and they are beyond the possibility of injury by net or trawl. In 1884 both the eggs and the young of food-fishes were, as a rule, wrapt in mystery. Now the eggs and larval stages of most have been described and figured, notably by Professor E. Prince, Mr. Cunningham, and Mr. Holt, and the growth in many cases followed to the adult condition. This experience, especially at St. Andrews, has demonstrated the comparative ease with which immense numbers of the eggs of valuable food-fishes can be artificially hatched and then placed in the sea. The Fishery Board's Marine Hatchery at Dunbar has done this on a large scale. Last year it was shown at Oxford that about twenty-seven millions of larval plaice, besides cod and flounders, were placed in the sea. This year about 38,615,000 larval plaice, 3,800,000 larval turbot, 2,760,000 larval cod, 2,500,000 larval lemon-dabs (often sold as soles), besides 600,000 larval dabs and flounders, and 450,000 larval haddock and whiting were 'planted,' making a total for the year of 48,725,000 fishes. The total for the two years is thus 75,285,000 fry placed in the sea, while the mortality was very small. Comparing this result with the totals and the expenditure on the other side of the Atlantic, it has been found that in two seasons the economically managed Scotch establishment pressed closely on the grand totals of twelve or thirteen years' work. The Americans, moreover, chiefly deal with the cod, a fish more easily manipulated, and which produces a far greater number of eggs than the plaice; and the same might be said of the Norwegians. The turbot and lemon-dab, again, are valuable fishes for the first time artificially hatched on a large scale. Dr. Fulton and the staff under him have thus made great progress. English soles have been successfully transferred to Scottish waters, many having been carried long distances, as from the Lancashire coast, where they were obtained through the courtesy of Professor Herdman. The distribution of the food-fishes has been carefully investigated at various stages, as well as their capture by the different instruments used in fishing, especially in connection with the variously sized meshes and hooks. Experiments on the vitality of the fishes after capture by trawl or by hook have also been made. Our knowledge with regard to the food of fishes has been largely increased and grouped under two heads: (1) food which is the product of the locality, and for the most part developed on the bottom; and (2) food which is floating or pelagic, and which might be brought considerable distances by currents. The food of fishes to a large extent primarily depended on plant-life, a wonderful cycle passing from diatom or algoid through the lower animal forms to fishes. Much information has also been ascertained on the subject of close times, as applied both to the herring and white fishes, and is available for legislative purposes. The majority of the mussel beds of Scotland, and some of those in England, have been surveyed and reported on, and the whole question put on a new footing—founded on an accurate knowledge of the reproductions of the mussel, for which we are mainly indebted to Dr. J. Hardie Wilson. A series of observations have likewise been made on oysters with a view to resuscitate exhausted beds, *e.g.*, those of the Forth, where careless administration has reduced an income of 15,000*l.* or more a year to 148*l.*, and this within less than a generation. Various cockle and clam beds have been similarly surveyed, and suggestions made for their conservation and improvement. Experiments in regard to the hatchings of lobsters have been made at Brodick, in Arran, and at Dunbar, and their development is being studied by Dr. Fullerton. Other experiments have been made on the preservation of bait after it was placed on the hooks, and also on the preservation of herrings and white fishes. An important series of physical observations has been carried out in the North Sea as to temperatures, currents, and other features of the water, the relations of these to the fishing grounds and the migrations of fishes. Lastly, a commencement has been made in determining the proportional number of the sexes of salmon entering the rivers at various periods, and their external differences, the determination of when and to what extent the muscles undergo changes during the growth of the roe and milt, so as to clear up the subject of the deterioration of the fish as food. The structure of the alimentary canal of the fish in connection with its cessation to feed and other points are also being studied. These complex investigations are in the hands of Mr. T. Tosh at Berwick-on-Tweed, Dr. Noel Paton, and the staff of the College of Physicians' Laboratory, Edinburgh, and in those of Dr. Alex. Brown, Aberdeen. Some persons think that the Universities, and not the Government, shoul dcarry out such investigations; but it need scarcely be said that the Universities have neither the means, the ships, nor the experienced staff distributed along the coast line and in constant touch with the subject, for efficiently dealing with it. A public department alone is capable of undertaking it with success, as the practice of other nations from America to Japan abundantly testifies.

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2. *On the Royal Dublin Society's Fishery Survey. By* Professor A. C. Haddon.

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3. *On the Fishery School at Ringsend, near Dublin. By* Professor A. C. Haddon.

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4. *Oyster Cultural Methods, Experiments and New Proposals. By* Bashford Dean, *Assistant U.S. Fishery Commission.*

The author spoke of the difficulties in spat collecting, and of some recent suggestions as to their obviation; of the lack of definite knowledge as to the most favourable physical conditions of the oyster's set; of questions of aëration, density, temperature, and silt deposit of the water during the spawning season. He referred to the difficulty in retaining the embryos in *bassins* and in determining the duration of the motile stage. The suggestiveness of the *mare piccolo* and of the closed lake of *Brénéguy;* the experiments in spat collecting of Rice, Saint-Sauveur, and more recent culturists, and the possible defects of the cultural methods lately patented in the United States were also discussed.

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5. *On Oysters and Typhoid: an experimental Inquiry into the effect upon the Oyster of various external conditions, including Pathogenic Organisms. By* Rubert W. Boyce, *M.B., M.R.C.S., Professor of Pathology in University College, Liverpool; and* W. A. Herdman, *D.Sc., F.R.S., Professor of Zoology in University College, Liverpool.*

Our motives in undertaking this investigation have been—

1. Purely scientific—the elucidation of the life conditions of the oyster, both under normal and abnormal environment.

2. Economic or technological—to trace the causes and effects of diseased conditions, with the view of determining what basis exists for the recent 'Oyster and typhoid' scare, (*a*) in the interests of the oyster fisheries, and (*b*) in the interests of the general public.

A. The objects, in detail, we had in view in entering on the investigation were as follows:—

1. To determine the conditions of life and health and growth of the oyster by keeping samples in sea waters of different composition—*e.g.* it is a matter of discussion amongst practical ostreiculturists as to what specific gravity or salinity of water, and what amount of lime are best for the due proportionate growth of both shell and body.

2. To determine the effect of feeding oysters on various substances—both natural food such as Diatoms, and artificial food such as oatmeal. Here, again, there is a want of agreement at present as to the benefit or otherwise of feeding oysters in captivity.

3 To determine the effect of adding various impurities to the water in which the oysters are grown, and especially the effect of sewage in various quantities. It is notorious that oysters are sometimes grown or laid down for fattening purposes

in water which is more or less contaminated by sewage, but it is still an open question as to the resulting effect upon the oyster.

4. To determine whether oysters not infected with a pathogenic organism, but grown under insanitary conditions, have a deleterious effect when used as food by animals.

5. To determine the effect upon the oyster of infection with typhoid, both naturally—*i.e.* by feeding with sewage water containing typhoid stools, and artificially—*i.e.* by feeding on a culture in broth of the typhoid organism.

6. To determine the fate of the typhoid bacillus in the oyster—whether it is confined to the alimentary canal, and whether it increases in any special part or gives rise to any diseased conditions; how long it remains in the alimentary canal; whether it remains and grows in the pallial cavity, on the surface of the mantle and branchial folds; and whether it produces any altered condition of these parts that can be recognised by the eye on opening the oyster.

7. To determine whether an oyster can free its alimentary canal and pallial cavity from the typhoid organism when placed in a stream of clean sea water; and, if so, how long would be required, under average conditions, to render infected oysters practically harmless.

B. The methods which we employed in attaining these objects were as follows:—

1. Observations upon oysters laid down in the sea, at Port Erin—

(*a*) Sunk in 5 fathoms in the bay, in pure water.
(*b*) Deposited in shore pool, but in clean water.
(*c*) Laid down in three different spots in more or less close proximity to the main drain pipe, opening into the sea below low-water mark.

These were to ascertain differences of fattening, condition, mortality, and the acquisition of deleterious properties as the result of sewage contamination.

2. Observations upon oysters subjected to various abnormal conditions in the laboratory.[1]

(*a*) A series of oysters placed in sea water and allowed to stagnate, in order to determine effect of non-aëration.
(*b*) Similar series in water kept periodically aërated.
(*c*) A series placed in sea water to which a given quantity of fresh (tap) water was added daily, to determine effect of reduction of salinity.
(*d*) A series of oysters weighed approximately, and fed upon the following substances, viz.:—

(1) Oatmeal.
(2) Flour.
(3) Sugar.
(4) Broth.
(5) Living Protophyta (Diatoms, Desmids, Algæ).
(6) Living Protozoa (Infusoria, &c.).
(7) Earth.

In this series of experiments the oysters were fed every morning and the water aërated, but not changed (evaporation was compensated for by the addition of a little tap water as required). The oysters were weighed from time to time, and observations made upon the apparently harmful or beneficial effects of the above methods of treatment.

[1] The oysters were kept in basins in cool rooms of constant temperature, shaded from the sun, both at the Port Erin Biological Station and also in the Pathological and Zoological Laboratories at University College, Liverpool.

(*e*) A series of oysters placed in sea water to which was added daily--

(1) Healthy fæcal matter.
(2) Typhoid fæcal matter.
(3) Pure cultivations of the typhoid bacillus.

The oysters were carefully examined to determine their condition, with special reference to condition of branchiæ, alimentary canal, adductor muscle, and viscera generally. The contents of the rectum, as well as the water in the pallial cavity, were subjected to bacteriological analysis to determine the number of micro-organisms present, as well as the identity of the typhoid or other pathogenic organisms.

C. The following is a summary of the results obtained so far :—

We consider that these results are based upon tentative experiments, and serve only to indicate further and definite lines of research. They must not be regarded as conclusive. We feel strongly that all the experiments must be repeated and extended in several directions.

Our experiments demonstrate :—

I. The beneficial effects of aëration—

(*a*) By the addition of air only ;
(*b*) By change of water ;

pointing to the conclusion that the laying down of oysters in localities where there is a good change of water, by tidal current or otherwise, should be beneficial.

II. The diverse results obtained by feeding upon various substances, amongst which the following may be noted. The exceedingly harmful action of sugar, which caused the oysters to decrease in weight and die ; whilst the other substances detailed above enabled them to maintain their weight or increase. The oysters thrive best upon the living Protophyta and Protozoa. Those fed upon oatmeal and flour after a time sickened and eventually died.

III. The deleterious effects of stagnation, owing to the collection of excretory products, growth of micro-organisms, and formation of scums upon the surface of the water.

IV. The toleration of sewage, etc. It was found that oysters could, up to a certain point, render clear sewage-contaminated water, and that they could live for a prolonged period in water rendered completely opaque by the addition of fæcal matter ; that the fæcal matter obtained from cases of typhoid was more inimical than that obtained from healthy subjects ; and that there was considerable toleration to peptonised broth.

V. The infection of the oyster by the micro-organisms. The results of the bacteriological examination of the water of the pallial cavity of the oyster, and of the contents of the rectum, showed that in the cases of those laid down in the open water of the bay the colonies present were especially small in number, whilst in those laid down in proximity to the drain pipe the number was enormous (*e.g.* 17,000 as against 10 in the former case). It was found that more organisms were present in the pallial cavity than in the rectum. In the case of the oysters grown in water infected with the *Bacillus typhosus*, it was found that there was no apparent increase of the organisms, but that they could be identified in cultures taken from the water of the pallial cavity and rectum fourteen days after infection.

It is found that the typhoid bacillus will not flourish in clean sea water, and our experiments seem to show so far that it decreases in numbers in its passage along the alimentary canal of the oyster. It would seem possible, therefore, that by methods similar to those employed in the 'Bassins de dégorgement' of the French ostreiculturist, where the oysters are carefully subjected to a natural process of cleaning, oysters previously contaminated with sewage could be freed of pathogenic organisms or their products without spoiling the oyster for the market.

It need scarcely be pointed out that if it becomes possible thus to cleanse infected or suspected oysters by a simple mode of treatment which will render them innocuous, a great boon will have been conferred upon both the oyster trade and the oyster-consuming public.

We desire to acknowledge the kind help of Mr. W. I. Beaumont in making some of the observations at Port Erin, and of Mr. Andrew Scott at Liverpool.

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6. *On the Oyster Culture in the Colne District.* *By* Dr. H. C. Sorby, *F.R.S.*

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7. *On Fish and Fishing Grounds in the North Sea.* *By* J. T. Cunningham, *B.A.*

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8. *The Organisation of Zoological Bibliography.* *By* Herbert Haviland Field, *Ph.D.*

Arrangements are now almost completed for the establishment of an international bibliographical bureau for zoology. This bureau, the organisation of which was begun some three years ago, will be located at Zürich, Switzerland. It will publish a series of bibliographical journals, as follows: 1, a fortnightly bulletin: 2, an edition of the bulletin printed on thin paper, and only on one side of the sheet, so that it may be cut up and used for other bibliographical elaboration; and 3, a complete card-catalogue of all zoological literature published *after* 1895. In addition, the 'Zoologischer Jahresbericht' will be federated with the undertaking, so as to afford an annual list of titles, arranged alphabetically by authors.

In the pamphlet edition the titles will be classified under a series of headings, corresponding to the systematic groups of animals. The cards will be of the standard library size, and will be essentially 'authors' cards.' They will, however, bear a set of simple symbols, which will permit them to be classified in one of several different ways, according to the special needs of each individual subscriber, viz. 1, alphabetically by authors; 2, systematically by groups of animals; 3, morphologically by organ systems; or 4, faunistically by zoogeographical regions. The system of symbols is so simple that the cards could be arranged by any laboratory boy or library assistant, no knowledge of the science being involved.

All the above classifications will be based upon a study of the text itself; and incidental observations, though not mentioned in the title, will be brought out and used as cross-references. Each chapter will then be complete in itself, for it will contain, as far as possible, all observations published on the subject, whether published as *whole papers*, or as *accessory notes* in a paper, whose major part is of a very different nature. In a word, the unit for the classification will be the individual observation paragraph, not the paper as a whole.

In various parts of the world the bureau will be aided by, 1, national committees; 2, correspondents; and 3, sub-bureaux. The national committees of several countries are already organised. They are to use their influence in securing for the bureau such publications as cannot be consulted in any library to which we have access—the Swiss libraries, that of the Zoological Station at Naples, and those of Leipzig. In case the journals themselves cannot be obtained they are to be reported by correspondents. It is, however, so manifestly in the interest of each author and of every publishing firm or scientific society to make its publications known that co-operation is assured. The matter has already been studied by the French and American committees in considerable detail, and they have found that it is perfectly possible to obtain the journals in the way indicated. There is no reason to suppose that England will show herself less ready to co-operate than these two nations. It seems certain that competent correspondents can be found. Several have indeed already offered to assume this burden. The sub-bureaux are being organised merely in those countries where the language presents exceptional difficulties—Bohemia, Hungary, Poland, and Russia. They will be maintained at the expense of the particular country involved, and are in large measure already realised.

The financial support of the bureau will come from several sources. The initial cost of organising the service will be borne by those who have undertaken this task. The current expenses must, however, be in part covered by subsidies from learned societies, &c. Thus the Naples Zoological Station has offered an annual grant toward the support of the bureau. In Switzerland a considerable annual subsidy is also offered to the bureau. In France a subscription has been opened under the auspices of the Société Zoologique de France, and has been subscribed to by several other societies. In the United States a similar course has been adopted, and the full sum asked for is already assured. In Russia the co-operation takes the form of a national sub-bureau; I mention it here merely because it was there that the first committee was nominated.

In England the following is needed: 1, a national committee to aid the bureau in all such emergencies as require direct local action; 2, a service of correspondents; and 3, a grant towards the support of the bureau. It is with a view to inducing English zoologists to meet these requirements that I take the liberty of bringing this matter to the attention of the British Association. It is reasonably certain that the enterprise will succeed, if we can only secure one half the support that has been secured in the United States or in Switzerland.

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9. *The 'Date of Publication' of Zoological Memoirs.* *By* Herbert Haviland Field, *Ph.D.*

The accepted rules of zoological nomenclature are based upon the so-called 'law of priority.' It is therefore of the greatest importance that what is meant by the 'date of publication' should be defined precisely. The rules adopted by the international congresses are more explicit on this point than most of the previous ones, and the precedent is set for adopting for convenience certain arbitrary rulings. Thus, neither the date at which a paper is presented before a learned society, nor the date of sending it to press is accepted. On the other hand, the rule does not specify whether the date of printing or that of *issue* is to be taken. In certain legal cases (patents, &c.) the decision seems to have been the former. This is, however, a date which it is impossible to verify in practice, and the latter seems, moreover, the more equitable ruling. I know cases in which the difference between the two dates amounts to nearly one year. It is therefore important to regulate this point in order to avoid future contestations.

I should like, then, to make the following propositions to the Committee of the Zoological Section:

(1) That the Committee recommend the date of *distribution* as the proper criterion.

(2) That the Committee recommend that zoological publications be recorded as well as published.

If the Committee decide to take this step, the new Bibliographical Bureau could readily undertake to record and publish with each paper the date at which it was *sent*—not received—and thus open the way for the ideal solution. This would be to make recording the basis of our nomenclature, rather than the mere publication. Such a ruling would, however, obviously only be possible *after* the practice had become general. We can to-day do nothing more than work towards that solution.

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10. *On Economy of Labour in Zoology.* *By* Thomas R. R. Stebbing, *M.A.*

Founding his case upon the presumed admission that the knowledge of natural history has increased, is increasing, and ought not to be diminished, the author argues that measures are now urgently required for facilitating the survey of this extensive and ever-extending body of information. He gives examples of the onerous conditions of study resulting from the existing state of scientific literature. He proposes that an effort should be made to gather into a succinct form all the most indispensable knowledge in each branch of zoology, instead of leaving each student to gather it as best he may from an unwieldy mass of miscellaneous writings.

The proposals now current for a new system of recording in zoology are cordially endorsed. As the uniformity, simplicity, and completeness aimed at by those proposals will, if successfully attained, give workers in general a clue through the maze of future discoveries, it is urged that at this parting of the ways the opportunity should be seized for dealing with past acquisitions. They need to be presented with the utmost conciseness to which skill and method can reduce materials so vast and various, and sometimes so vague and so redundant.

The point is insisted on that, however lowly may be the place in science of systematic zoology, it is after all a department which must exist. Although the service indicated is needed for all the other departments, systematic zoology is the one to which it is most necessary and can most easily be rendered. At the same time the undertaking is not of a character to promise an immediate return of commercial profit. But just as great public works are carried out by Government at the expense of the nation, so this scientific work appeals to the fostering care of those societies which are by their eminence entitled and by their financial position enabled to act for the commonwealth of science.

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11. *On the Septal Organs of* Owenia fusiformis. *By* Professor G. Gilson.

The object of this communication is to call attention to certain peculiarities presented by the septa of *Owenia fusiformis*, and to obtain information from the anatomists who may have observed similar features in other tubicolous annelids.

These septa, with the exception of the first, or cephalic, and the most remote ones in the tail, are all perforated. Each of them presents two pores, through which the adjoining segments communicate.

These pores are provided with a muscular apparatus, very powerful in certain of the septa, and sometimes rather complicating their structure.

The second septum, for instance, which is the most muscular of all, contains, on each side of the ventral median line, an enormous ovoid mass of muscles, the fibres of which run in various directions. Through these muscles passes a tiny canal. This septal canal is very sinuous in its course through the muscular organ, and its existence is far from being easily recognised, owing to the state of violent contraction in which the muscles are always found in sections. There is no doubt, however, that the septal canals may open widely enough to allow the eggs to pass and to reach the fifth segment of the body, which is the only one that communicates with the exterior, through the modified nephridia described in the author's paper last year at Oxford.

Besides the canals and their muscles, the fifth septum contains a semicircular muscle which seems to be intended to constrict the intestine, which, just where it pierces the septum, becomes suddenly very narrow and acquires a very thick muscular coat.

All the septa present similar structures, more or less complicated, until in the posterior ones the septal pores are reduced to a short perforation, surrounded by a thin muscular ring.

But in the fifth and sixth septa a new feature appears: the muscular, sphincter-like mass on each side is joined by a tubular ingrowth of the epiderm. This tube protrudes into the septal tissue until it meets a cavity which communicates with the septal canal and with the anterior segment.

Up to the present the author has not been able to detect any aperture at the extremity of this epidermic tube; but he is almost certain that such an aperture really exists, and may open under the action of certain muscular fibres.

The septal canals, as stated above, are the way through which the eggs reach the fifth segment; but the fact that they exist in the second septum, whilst the segment in front of this has no gonad, shows obviously enough that they must have another function.

The author ventures to offer the following explanation as to the function of all these well-guarded septal pores, and of the epidermic tubes of the fifth and sixth septa.

It is a fact easily observed that the worm swells or dilates its body when it wants to adhere to the sheath in which it lives. And in this way it opposes such a powerful resistance, that it is quite impossible to pull it out of its tube without breaking its body in pieces; and when a part of the body has been cut off, the remaining segments do not relax at all, but remain as turgid and resisting as before. This shows that the various segments of the body may swell or relax quite separately.

The septal organs are the valves which allow the coelomic fluid to flow in or out when they are open, but impose an insuperable resistance to its exit when the worm wants to dilate one or two segments separately.

The paired tubes of the fifth and sixth septa are very likely intended to take in a small quantity of water from the outside, to be mixed with the coelomic fluid, when a larger quantity of it happens to be required.

To sum up, although these researches and experiments are not finished, we have sufficient reason to consider the curious septal organs of *Owenia* as valves intended to regulate the pressure in the separate chambers of the perivisceral cavity, and to eventually divide entirely from one another those which at a given moment the animal desires to dilate under the contraction of the muscular coat of the skin.

If this view is correct, we must regard the body of *Owenia* as a very elaborate hydraulic mechanism.

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12. *On a simple and efficient Collecting Reservoir for the Surface Tow-net. By* W. Garstang.

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13. *On the Statistics of Wasps. By* Professor F. Y. Edgeworth.

The number of wasps in a nest may be inferred from the number issuing per minute: if (1) we know the average time occupied by a wasp in the cycle of operations between two successive exits, (2) we assume that the whole population is occupied in keeping up the traffic.

(1) The author has collected some statistics bearing on the first datum. The average time occupied by the wasps which he has observed in loading is six minutes—varying from two minutes, when the load consists of liquid sweets (of Sir J. Lubbock's observations), to ten minutes, when dried marmalade has to be hewed. The average interval between the departure of a laden wasp and the return of the same wasp for another load is—with much less variation—nine minutes. Accordingly the mean periodic time for a wasp employed in collecting sweets may be assumed to be about fifteen minutes. This result is verified and corrected by other methods applicable to all kinds of employment—*e.g.*, stopping the entrance of a small nest and noting the times of arrivals. The corrected figure is 20.

If the number of wasps issuing per minute is X, the total number would be 20 × X, if assumption (2) held. But how inadequate it is is shown from the fact that the same nest within a short period shows very different rates of traffic. Thus a nest which at the beginning of a week had a traffic (entrances + exits) of twenty per minute, had, after three days, a traffic of sixty per minute; and, after two more days, a traffic of only twelve per minute, we can at best infer that the *maximum* observed rate of exit per minute, multiplied by 20, gives a *minimum* lower than the total number in the nest.

In some cases examined by the author the minimum was found to be very much below the actual number. Thus a nest for which the observed *maximum* average rate of issue was eleven per minute, was found—when the whole population was killed and counted—to have contained, in round numbers, 600. A nest of which the maximum observed rate of issue was thirty per minute, was found to have contained 1,600.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Papers were read:—

1. *On Insect Transformations. By* Professor L. C. MIALL, *F.R.S.*

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2. *On Mounting Marine Animals as Transparent Lantern Slides. By* H. C. SORBY, *LL.D., F.R.S.*

For some years past the author has devoted much time to this subject, when on board the yacht *Glimpse*. The methods which give good results vary much in the case of different animals. Some must be arranged on the glass and dried quickly soon after having been caught, whereas others (like Medusæ) must be treated over and over again with moderately strong alcohol to dissolve out all the salts. In some cases various staining materials must be used to bring out the structure, and some should be decalcified.

Usually the animals are killed by keeping them for a short time in diluted alcohol, and are then arranged on the glass; and, after as much of the alcohol as will drain out is lost, they are dried in a current of air. The edges dry first, and so adhere to the glass that, on further drying, the animals become thin without any material change in form. In some cases they must be thoroughly soaked with clear gum before becoming quite dry. Finally, when quite dry, they are mounted in Canada balsam, and the edges of the cover glass very completely bound round so as to prevent the balsam running out when heated in the lantern.

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3. *Description of Methods for Collecting and Estimating the number of Small Animals in Sea Water. By* H. C. SORBY, *LL.D., F.R.S.*

The author described the methods he employs to collect moderately small animals by means of a brown holland bag, at the bottom of which is an arrangement so that brass wire sieves with meshes of various sizes can be fixed by a sort of bayonet joint. Through these the water flows readily, and the animals are easily washed off into a small bulk of water.

Another method is to collect water in a special bottle at various depths from the surface to bottom, and to pour $2\frac{1}{2}$ gallons through a sieve having openings about $\frac{1}{100}$ of an inch in diameter From this the animals are washed off into a few ounces of water. The numbers of the various kinds are afterwards counted in a small deep narrow trough filled over and over again until the whole quantity has been examined. The number of each kind per gallon can then be easily calculated.

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4. *On the Conditions affecting Bacterial Life in River Water.* *By* E. Frankland, *D.C.L., F.R.S.*

In a series of monthly observations, the author found that the microbes in the water of the Thames and Lea are, as a rule, much more numerous in winter than in summer. There are three conditions, to any one of which this difference might be attributed, namely, temperature, sunshine, and rainfall. By a series of graphic representations these three conditions are disentangled from each other by placing the results of the microbe determinations in juxtaposition with (1) the temperature of the water at the time the samples were taken; (2) the number of hours of sunshine on the day and up to the hour when the sample was drawn, and on the two preceding days; and (3) the flow of the Thames over Teddington Weir on the same day expressed in millions of gallons per twenty-four hours. Although the graphic representations were confined to the Thames, the conditions affecting bacterial life in this river are doubtless equally potent in other rivers and streams.

These graphic representations afford definite evidence as to which of the three conditions just named has the predominant influence upon bacterial life in river water. They show that whilst coincidences between a high number of microbes and a low temperature and absence of sunshine are not wanting, some other condition entirely masks the effect, if any, of temperature and sunshine. This condition is the amount of rainfall higher up the river, or, in other words, the volume of water flowing along the river-bed.

The interesting observations of Dr. Marshall Ward leave no doubt that sunlight is a powerful germicide; but it is obvious that its potency in this respect must be greatly diminished, if not entirely annulled, when the solar rays have passed through a stratum of water of even comparatively small thickness before they reach the living organisms; and the author shows, by a series of experiments upon the effect of sunlight upon the river water at various depths from the surface, that the germicidal effect of sunlight on Thames microbes is nil at depths of one foot and upwards from the surface of the water, even when the river is in a comparatively clear condition. It cannot, therefore, excite surprise that the effect of sunshine upon bacterial life in the great mass of Thames water should be nearly, if not quite, imperceptible.

The author also calls attention to the powerful effect of storage reservoirs in the diminution of the number of microbes in river water, and to the very important bearing which this fact has upon the storage of flood water in the Thames Valley, for it leaves no doubt that storage for a month or two of the flood waters would effect such a bacterial improvement as would render the water of good quality for domestic use. By the construction of such storage works, the capacity of the Thames basin for the supply of good potable water to London would be enormously increased.

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5. *On the Exploration of the Islands of the Pacific.* *By* Prof. A. C. Haddon.

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6. *On the Coccidæ of Ceylon.* *By* E. E. Green.

Since the publication of his papers on *Lecanium viride* and *Chionaspis biclavis*, the author has devoted three years to continuous work upon the Coccidæ of Ceylon. He has recorded 150 species, of which fully two-thirds were new, and found it necessary to create two or three new genera for the reception of strikingly aberrant forms. He referred to newly discovered organs in the encapsulated male, and remarked that he had in preparation a monograph, to be illustrated by 120 or more plates, giving figures of adults and larvæ drawn from life. On his return to Ceylon he contemplates continuing the investigation in both its scientific and economic aspects.

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7. *Criticisms on some points in the Summary of the Results of the 'Challenger' Expedition.* By Dr. H. O. Forbes.

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8. *Observations on the Marine Fauna of Houtman's Abrolhos Islands, Western Australia.* By W. Saville-Kent, *F.L.S., F.Z.S.*

Mr. Saville-Kent's investigations of the marine fauna of Houtman's Abrolhos Islands were associated with a visit he paid them in his capacity of Commissioner of Fisheries to the Western Australian Government, and were conducted with the particular object of advising that Government as to the conditions and prospects the adjacent waters presented for the establishment therein of profitable oyster or mother-of-pearl shell fisheries.

Houtman's Rocks, or Houtman's Abrolhos, as they are variously charted, are so named after one of the early Dutch explorers in contradistinction to a coral group, also known as the Abrolhos, lying off the coast of Brazil. The island group discussed in this paper is a small archipelago, chiefly of coral origin, situated between the latitudes of 29° and 30° S., about thirty miles west of Champion Bay and the important Western Australian port of Geraldton.

As a result of his investigations Mr. Saville-Kent found that the ordinary Australian rock oyster, *Ostræa glomerata,* occurred there in tolerable abundance and under conditions that would justify its being made the subject of systematic cultivation. The smaller West Australian variety mother-of-pearl shell allied to or identical with *Meleagrina imbricata* occurs very sparingly on the Abrolhos Reefs, but in the Commissioner of Fisheries' opinion was not worthy of serious attention in face of the unexpectedly favourable conditions he discovered to obtain there for the introduction and acclimatisation of the larger and more valuable species, *Meleagrina margaritifera.* This decision was arrived at as the outcome of an investigation of the associated marine fauna, and which was found to present features of high interest from both a utilitarian and a biological standpoint.

The existing pearl and mother-of-pearl shell fisheries of Western Australia, as associated with the larger species, have not hitherto extended further south than Exmouth Gulf, in about lat. 22° S., and are consequently limited to the Tropics. The fishery for the smaller species, *Meleagrina imbricata,* is confined chiefly to Shark's Bay, three to four degrees south of Exmouth Gulf, and has in consequence of the wasteful depletion of the banks in former years been reduced to a comparatively low state of productiveness. Among other operations initiated by Mr. Saville-Kent, with the object of resuscitating the Shark's Bay fishery, has been the experimental transportation to it and cultivation of the large tropical pearl shell *Meleagrina margaritifera.* These acclimatisation experiments, although initiated only on a small scale, have been attended with complete success. The large mother-of-pearl shell has not only shown its capability of thriving in the colder waters of Shark's Bay, but has within a year of its transportation to this extra-tropical area commenced to freely propagate.

The site selected for the foregoing experiments in Shark's Bay was the neighbourhood of extensive banks of coral growths pertaining to the genus Turbinaria, and from which reefs Mr. Saville-Kent obtained the remarkably large specimens of this Madrepore that are now on view in the exhibition galleries of the Natural History Museum, South Kensington. It has been determined by Mr. Saville-Kent in the course of his Australian explorations that the genus Turbinaria represents the group of Madrepores which in Australian waters enters most extensively into the composition of coral reefs in the colder or extra-tropical limit of their distribution. This predominance of Turbinarians had been found by him to obtain at Wide Bay, on the southern outskirts of the Great Barrier Reef in Queensland; in the colder though more northern waters at the head of the Gulf of Carpentaria; and, finally, in the Shark's Bay district of Western Australia.

The conditions which permitted the successful acclimatisation of *Meleagrina margaritifera* in Shark's Bay were found by Mr. Saville-Kent to be still more favourably fulfilled around Houtman's Abrolhos. In and among this island group, notwithstanding the fact that it lay some two degrees south of Shark's Bay, the character and composition of the coral reefs proved to be entirely distinct. In place of the extra-tropical Turbinariæ the corals of the Abrolhos Reefs comprise, as in essentially tropical districts, numerous varieties of branching Madreporæ, or so-called Stag's-horn corals, commingled with many species of Porites, Montipora, Pocillopora, Seriatopora, Cœloria, Mussa, and other intra-tropical reef-building species.

A yet more remarkable phenomenon, however, is recorded by Mr. Saville-Kent in connection with the marine fauna of Houtman's Abrolhos. This is the circumstance that he discovered on its reefs three of the most valuable economic species of Holothuridæ or Bêche-de-mer, identical with types that are systematically collected in Torres Straits, and throughout the northern moiety of the Queensland Great Barrier Reef, but which are unknown to the coastal reefs of Western Australia further north, and where their place is taken by a distinct and much less valuable commercial species.

The fish fauna of Houtman's Abrolhos, while corresponding to a large extent with that of the temperate Australian seaboard, as instanced by such genera as Pagrus, Aulopus, and Seriola, is also associated with many essentially tropical species, including, notably, a large assemblage of brilliantly coloured Labridæ, or Parrot-fishes. Certain of these Labridæ, while not obtained by Mr. Saville-Kent in collections made among the mainland reefs of Western Australia, were familiar to him, as in the case of the Holothuridæ, as denizens of Torres Straits and the northern region of the Great Barrier Reef.

The anomalous character of the marine fauna of Houtman's Abrolhos as herein defined can only be accounted for by the assumption that an ocean current setting in from the equatorial area of the Indian Ocean penetrates as far south as this island group, and has borne with it the floating embryos of the Holothuridæ and Cœlenterates, &c., that so characteristically distinguish it. A reference to the Admiralty charts, dealing with the ocean currents of this region, supports this interpretation to a considerable extent; indicating, as a matter of fact, a prevailing northerly set along the western coast of Australia, but at the same time a distinct southerly intrusion of the waters of the Indian Ocean at some distance off shore down towards and closely approaching Houtman's Abrolhos. In further support of this interpretation Mr. Saville-Kent also determined by synchronous readings of the thermometer at the coldest season of the year, July, that as great a difference as from ten to fourteen degrees Fahrenheit distinguished the surface temperature of the sea at respectively the Abrolhos Islands and in Champion Bay. Mr. Saville-Kent remarks, in conclusion, that much scope is yet left for further investigation in this direction; while with respect to the anomalous character of the marine fauna it would be greatly to the advantage of marine biological science if a thoroughly exhaustive investigation thereof could be carried out.

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9. *On Hereditary Polydactylism.* *By* Dr. Gregg Wilson.

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10. *On the Reproduction of the Common Crab.* *By* Dr. Gregg Wilson.

TUESDAY, SEPTEMBER 17.

The following Papers were read:—

1. *Observations on Instinct in Young Birds.* *By* Professor Lloyd Morgan, *F.G.S., Assoc.R.S.M.*

This paper dealt with observations on young moorhens, chicks, martins, and swallows with a view to determine how far the activities involved in locomotion (swimming, diving, running, flying), in feeding, bathing, &c., are instinctive or congenital in their definiteness; and how far the definiteness of these and other activities is a matter of individual acquisition. Observations were also made on congenital and acquired timidity. While the performance of these activities has a congenital basis they are perfected by individual acquisition. There is no instinctive and congenital avoidance of insects with warning colours; that appears to be entirely the result of individual experience. There seems to be little or nothing in the observations to afford any material support to the view that the instinctive activities result from the inheritance of what is individually acquired.

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2. *Notes on the Early Development of the Ganoids,* Lepidosteus, Acipenser, *and* Amia. *By* BASHFORD DEAN, *Instructor in Biology, Columbia College, New York.*

A. *Segmentation of the Egg.*—The earlier cleavages conform to the usual plan of Teleost and Amphibian:—Lepidosteus and Amia meroblastic, Acipenser superficially holoblastic. Questions as to the kinships with the yolk type of the Elasmobranch on the one hand, and with that of the Teleost on the other, were discussed.

B. *Blastula, Gastrula.*—The relations of the different forms of Ganoidean blastula were shown in diagrams. The blastula of Lepidosteus and Shark, of Amia and Teleost are similar. Comparison of Ganoidean gastrulæ: the diagrams show structures diverging from the type of Lepidosteus towards that of Teleost.

C. *General Mode of the Formation of the Embryo.*—Shark-like characters of Lepidosteus, flattened growth of Acipenser, and Teleostean features of Amia.

D. *Conclusions.*—Developmental nearnesses of Lepidosteus to the Elasmobranch and of Amia to the Teleost, and the evidence on the side of embryology for connecting the line of the Teleosts with that of the Ganoids, as well as for drawing more closely together the Elasmobranchian and Ganoidean phyla.

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3. *On some questions relating to the Morphology and Distribution of Medusæ. By* DR. OTTO MAAS.

Dr. Otto Maas exhibited some plates from his monograph of the 'Albatross' Medusæ, and discussed some questions arising from the study of these Pacific forms.

The collection, though not very rich, is of interest in various points:

1. Morphological. 2. Zoogeographical. 3. Bionomical.

1. Amongst 18 species 9 are new, several of them peculiar forms, for instance, a representative of the aberrant genus *Homoioneme*, established 1892 for some forms of the 'Plankton' Expedition. Amongst the Acraspeda we find the genera *Periphylla*, *Atolla*, and others which are of importance for the morphology of the whole group, and which have induced Claus and Vanhöffen to a reformation of Häckel's system. The previous authors could not study the genital and sense organs; a detailed study of these shows that we can trace a line of relationship from the primitive Lucernaridæ through forms like *Periphylla* and *Nauphanta* to the higher Discophora, forms like *Atolla* lying a little to the side of the line, whilst *Charybdea* is totally away from it. The study of the canal system of the Periphyllidæ and their relations shows some primitive features in correspondence with the embryology of the higher forms, *i.e.*, the interruption of the continuous entodermic cavity at four interradial points by the invagination of the 'Trichterhöhlen.'

2. The Medusæ have been caught in an oceanic basin hitherto scarcely explored. In a map of the distribution of the Cathammata given by Vanhöffen the part of the Pacific navigated by the 'Albatross' is an empty gap which is now filled up.

The list of Acraspeda species shows a striking resemblance to that of the 'Challenger' Expedition. The so-called 'deep sea Medusæ' seem to have a very wide geographical distribution; they have been brought home by the 'Challenger,' the 'Vettor Pisani,' the 'National,' and the 'Albatross,' but it is to be noticed that they have been caught only in those really *oceanic* explorations, so, if they are, not deep-sea Medusæ, they are certainly not forms of the shallow water.

Amongst the Polypomedusæ we find a very close relationship between Atlantic and Pacific species. The different species of one genus are in general much more difficult to distinguish than amongst the Trachomedusæ. This perhaps may be explained by the effective power of passive dispersal.

3. For the first time a great number of sketches of living material of the Periphyllidæ, &c., had been obtained on board. All these show the dark purple colour, generally attributed to deep sea animals. The explanation for other forms is, that in the green phosphorescent light of the abysses, purple is the complementary colour, which makes the animal invisible, and acts as a protective colour. It would be dangerous to conclude from this that Periphylla, &c., are deep-sea forms. They have been brought up in an open trawl from a great depth, but the closed part of the net contained no Medusæ. If a haul from a great depth contains forms which did not occur in surface hauls, these forms do not necessarily come from the abyss, for they might have been caught on the way to the surface. Our knowledge of the pelagic life of the surface is still so incomplete that every expedition brings us new species, as has been shown in the Copepoda, Medusæ, and other groups of the 'Albatross' Expedition.

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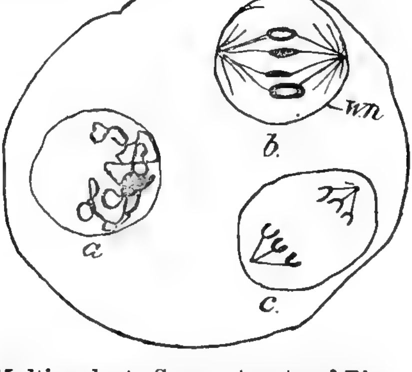
4. *On the Spermatogenesis in Birds. By* J. E. S. Moore.

The observations were made to ascertain whether the course of the spermatogenesis in birds was essentially similar to that of other vertebrates recently examined. It was found that in two points of chief importance, namely, the manner of numerical reduction of the chromosomes and the alternation of the homo- and heterotype divisions, the spermatogenesis of birds is closely similar to that of the remaining vertebrate forms.

During the first heterotype division, which corresponds to the division of the growing cells in Mammals and of the great spermatocytes in Elasmobranchs and Amphibia, the spermatic elements of pigeons show a marked tendency towards the formation of multinucleate masses. One of the most interesting features appertaining to these bodies is that the spindle-figure during the division of their nuclei appears to originate entirely within the nucleus, since the nuclear wall can be distinctly seen after the spindle-figure has been fully formed. The stages in the division may be diagrammatically represented thus:—



Multinucleate Spermatocyte of Pigeon.

(*a*) Nucleus in synaptic phase. (*b* and *c*) Spindle-figures. (*wn*) Nuclear wall.

The advent of the great heterotype mitosis is always preceded during the spermatogenesis by the peculiar convoluted and lop-sided figure (*a*) which is here, as elsewhere, characteristic of what I have previously termed the 'synaptic phase.'

The whole course of the spermatogenesis appears to correspond more closely with that of Elasmobranchs than of Mammals, since there appear to be two generations and one division after the synapsis before the spermatozoa are complete.

As in Elasmobranchs and Mammals, the number of the chromosomes appears to be reduced during the synapsis, and to be then determined for succeeding divisions, just as in the case of plants.

The spermatogenesis of birds supports in every way the conclusion first put forward by Strassburger, which is at present gaining ground, namely, that the process of numerical reduction in the chromosomes is not brought about by any division at all, and is similar for both animals and plants.

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5. *On the Development of the Teeth in Certain Insectivora.* *By* M. F. WOODWARD, *Demonstrator of Zoology, R.C.Sci. Lond.*

In the hedgehog the author describes vestigial calcified milk predecessors to the third upper incisor, the lower canine, and the first pre-molar of both upper and lower jaws, and an uncalcified vestige of the milk predecessor of the second lower incisor, thus extending Leche's observations and confirming his later conclusion that the adult incisors, canines, and pre-molars all belong to the third or replacing tooth series. In addition, a vestigial anterior lower incisor and a third lower pre-molar were observed. Indications of three dentitions are described for the molar series, the molars being referred to the third or replacing dentition.

The teeth of *Gymnura, Sorex, Talpa, Centetes,* and *Ericulus* are also dealt with, and the following points more especially noted :—

1. The presence in *Gymnura* of five pre-molars in both upper and lower jaws, represented in both dentitions.

2. The absence of the alleged milk predecessor to the first pre-molar of *Talpa* described by Spence Bate, that tooth being shown to be itself a milk tooth.

3. The development, in all cases, of the successor to the fourth pre-molar between the 'deciduous pre-molars 3 and 4.' The facts associated with this appear to indicate that the so-called 'deciduous pre-molar 4' is a precociously developed molar, and that the tooth which replaces it is a much retarded pre-molar of the milk series.

Two sets of calcified teeth are shown to be for the greater part developed among Insectivores, and it is characteristic of them that there is a tendency towards reduction of the milk set with early development of the replacing dentition.

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6. *On the Mammalian Hyoid.*[1] *By* Professor G. B. HOWES.

The author proved from the study of *Nasua* that the small bone attached to the paroccipital process in *Lepus* and *Procavia* (*Hyrax*), independently described by Krause and Brandt, is in reality the styloid, and showed that the discovery enables us to recognise two distinct culminating types of modification of the hyoid of mammals, viz. (i.), the *protero-stylic*, known only in man and the marmosets, and (ii.) the *opistho-stylic*, known only in the rodents mentioned. Reviewing the subject more generally, he called attention to the presence of a considerable tympano-hyal, occupying a novel position, in *Cholœpus*, and he exhibited the hyoid of a young rabbit, the body of which was subdivided by a transverse suture, probably indicative of the original demarcation-line between its two component 'copulæ.' A classification of the types of mammalian hyoid was submitted.

[1] Paper will be published in *Jour. Anat. and Phys.*, Jan., 1896.

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7. *On the Poison Apparatus of Certain Snakes.* *By* G. S. West, *A.R.C.Sci. Lond.*

The author describes, in thirteen genera of Opisthoglypha, a gland, which, there is every reason to believe, is homologous with the poison gland of the Viperine and Proteroglyphous types. The course of the poison duct and its detailed relationships to the teeth are dealt with, the latter being established through the mediation of a cavity enclosed within muscular folds, and so effected that loss of the tooth does not in any way result in injury to the duct. The distal portion of the duct is shown to be secretory and mucus-forming.

In the marine snakes (Hydrophiinæ) the poison gland is shown to be more or less free from the supra-labial, and to consist of longitudinally disposed tubules converging anteriorly towards a central duct. The latter is shown to become enlarged anteriorly, enclosing a cavity in front of the bases of the grooved teeth having muscular walls and specialised for purpose of communication with the grooves.

Certain vascular folds of the buccal mucous membrane are described, which occupy the interstices between the teeth, and are probably analogous to the villous processes occurring in the mouths of certain soft-shelled Chelonians.

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8. *On the Value of Myology as an Aid in the Classification of Animals.* *By* F. G. Parsons, *F.R.C.S., Lecturer on Comparative Anatomy at St. Thomas's Hospital.*

The paper contains a short notice of the reasons which induce Systematists to place little reliance on the study of muscles. It then reviews some of the muscles in the great order of Rodents, and points out how closely they correspond in animals which are nearly related, and how little the different modes of life of their possessors affect them. The ease with which different sub-orders and families of Rodents can be distinguished by a study of their muscles is next noticed, and finally the test of myology is applied to the family of Dipodidæ, the position of which is still unsettled.

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9. *On Ultimate Vital Units.* *By* Miss Nina Layard.

Section E.—GEOGRAPHY.

President of the Section—H. J. Mackinder, M.A., F.R.G.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

This is a memorable year for English students of geography. We have entertained in London for the first time a great gathering of our foreign colleagues, and have presented to the British public the unfamiliar spectacle of a geographical meeting, in which scholars and professors were as prominent as explorers. As a nation we may justly claim that for several generations we have been foremost in the work of the pioneer; nor need we view with dissatisfaction our contributions to precise survey, to hydrography, to climatology, and to biogeography. It is rather on the synthetic and philosophical, and therefore on the educational, side of our subject that we fall so markedly below the foreign and especially the German standard, and it is for this reason that we may regard the Sixth International Congress as a noteworthy object lesson for English geographers and teachers. The time seems, moreover, to have been ripe for some such stimulating influence. To indicate a few signs only of rising courage among our geographers, and of sympathy on the part of the public, I would draw your attention to the institution of afternoon meetings in Savile Row for the discussion of technical questions, to the success of the new Geographical Journal, notwithstanding its geographical as opposed to merely 'adventuring' flavour, to the recent formation of a geographical association of Public Schoolmasters, and to the demand for addresses on the teaching of geography on the part of the local branches of the Teachers' Guild. Facts are reminding us once more that the lapse of a certain time is essential to the rooting of a new idea, and we may thank the geographical veterans of 1869 for sowing seed the fruit of which we are now harvesting. That I am not alone in my interpretation of present tendencies is clear from the emphatic opinion of the President of the Royal Geographical Society expressed in his last annual address, that 'the time is approaching for a reconsideration of the educational policy of the Society.' It would almost seem that we are nearing a development of geographical education not unlike that which nine years ago followed on the publication of Mr. Keltie's valuable Report. At that time two of my predecessors in this chair, Sir Frederick Goldsmid and Sir Charles Warren, thought it not unfit to make education the chief theme of their addresses, and encouraged by their example I venture, under present circumstances, to call your attention once more to that subject. Since 1886 and 1887, however, much has happened, and we no longer need to discuss the more elementary teaching of geography. I propose, therefore, to treat of comparative and philosophical geography in relation especially to secondary and university education, and it seems to me that an historical rather than an *a priori* discussion gives best promise of result.

The middle of the 18th century marks an important epoch in the history of geography. In ancient times Ptolemy and Strabo grasped the system and possibilities of our science, but they failed to build high from lack of a broad foundation of precisely recorded facts. Subsequently, geography had its Dark Ages and its Renascence in harmony with the general trend of human affairs. By the end of the 16th century Mercator and Ortelius had somewhat more than recovered the Greek position, but still, for another century and a half, geographers wrestled with essentially the same problems as had presented themselves to the ancients. The observers ascertained latitudes and longitudes with ever-increasing precision, the cartographers projected the observed positions on their maps with growing happiness of compromise, and the scholars sought, with the prodigious industry characteristic of the age, to identify the sites mentioned by the ancient authorities. Three names—Harrison, D'Anville, and Varenius—in the several fields of observation, cartography, and scholarship, may be taken as completing this stage of development, although, as is always the case, the new and the old overlapped. In 1761 the chronometer was added by Harrison to the magnetic compass, the log-line, the sextant, and the theodolite, and thus was completed the observer's equipment. In the same year D'Anville published his *Atlas Moderne*, in which (besides a fidelity of outline greater than that of his predecessors Delisle and Homann) he brought to bear a mechanical finish and a criticism of data that were new to cartography. Only a few years earlier, in 1755, there appeared in Paris a French translation of the *Geographia Generalis* of Varenius, first published at Amsterdam in 1650, edited for Cambridge in 1681 by Sir Isaac Newton, and reprinted again and again for three generations as the masterpiece of the 'scholarly' geographers. Thus when George III. was still young, the *horizontal* outlines of the map of the world had taken their now familiar form, and school geography consisted of 'the use of the globes' with some small attention to classical topography.

What made the 18th century a transition age of such importance to geography was the realisation of new problems, which both Antiquity and the Renascence had either neglected or utterly failed to solve. These problems allow of most general expression by the use of three convenient terms, two of them lately imported from Germany—lithosphere, hydrosphere, and atmosphere—the first implying the rock globe whose surface is both land and sea-bed, the other two denoting the external envelopes. The geographer is concerned with the atmosphere, the hydrosphere and the surface of the lithosphere. His first business is to define the *form*, or relief, of the surface of the *solid* sphere, and the *movements*, or circulation, within the two *fluid* spheres. The land-relief conditions the circulation, and this in turn gradually changes the land-relief. The circulation modifies climates, and these, together with the relief, constitute the environments of plants, animals, and men. Shorn of complexities, this is the main line of the geographical argument. In the language of Richthofen, the earth's surface and man are the terminal links. It is clear that all depends on the accuracy of the first premises—the form of the lithosphere and the movements within the hydrosphere and atmosphere. Before last century geographers ascertained the horizontal elements in form, but neglected the vertical. In the matter of outline, the maps of D'Anville are an immense improvement on those of Ortelius, but they exhibit essentially the same almost child-like methods for the depiction of relief which had been employed by Buckinck in the 1478 edition of Ptolemy. Until this was remedied the whole superstructure of comparative and philosophical geography lacked any real basis.

Like the letters of the alphabet, conventional hill-shading was evolved from pictures rather than invented. The great atlas of Germany, published at Nuremberg in 1753 by the successors of Homann, consisting as it does of maps engraved in various years extending from 1718 to 1753, shows admirably almost every stage in the evolution. Other striking evidence may be seen in the chart of New Zealand drawn from Captain Cook's surveys, and reproduced by Admiral Wharton in his edition of Cook's Journal. Side by side on the same chart, we have the 'ant-hills' of Buckinck and Ortelius, and the 'caterpillars' of modern maps; but the latter, like degenerate animals with rudimentary organs, still retain clear marks of their origin. The 'ant-hills,' elsewhere sown evenly over the land-surface, are in certain parts drawn into chains and foreshortened, or in modern railway parlance 'telescoped.' One step more—the confusion of the lines of slope-shading with those of hill-outline—and the pictures would be conventionalised, all signs of origin would be lost, and students who had never seen a great mountain-range would be led to think of it as a wall-like ridge. Even 'ant-hills' are preferable to the 'caterpillar' in its crudest form.

An indication of the importance attached to the new problem of relief is to be seen in the fact that, before the method of hill-shading or hatching had been perfected, the method of horizontal contouring had already been invented. In 1737 Philip Buache, a French geographer of remarkably original mind, produced a contoured chart of the English Channel. Contour lines represent what would be coast lines were the sea to rise or fall to the level indicated, and it was natural that this device should first be applied to the mapping of the sea-bed rather than the land. In 1791 Dupain Triel drew a contoured map of France. But already in 1783, as Mr. Ravenstein pointed out in his address at the Cardiff meeting, Lehmann had combined the two systems, and, by superimposing hachures upon contours, and making the depth of shading proportional to the closeness of the contours, had produced a map which, while yielding to the popular requirements, rested on a scientific basis. Contoured maps, in which names are few or absent, can now, however, be made to rival in pictorial suggestiveness those which are shaded, and such maps are the more valuable in that they are not only structurally correct, but that they can be read also with accuracy and ease. Some of the sheets of the American Geographical Survey may be cited as excellent examples of graphic effect produced by contours only.

Ptolemy's knowledge of the theory and methods of cartography far outran the positive materials at his command for the mapping of the known world. In the same way the methods of depicting relief, though so recently developed, already at the end of last century more than sufficed for the presentment of the recorded data. As was seen in the case of Ptolemy, there are peculiar dangers in the possession of an engine more powerful than is needed for the work in hand. In 1783 Frnace was the only country in the world with a completed map based on systematic and detailed surveys. A relief-map like that of Dupain Triel was possible only in such a country. But in 1756 Philip Buache had already launched a general theory of relief resting on the conception of river basins, and had enriched geography with the terms 'water-parting' and 'plateau.' In the absence of positive knowledge, what more natural than that cartographers should make illegitimate use of the theory of Buache, and should assume that in the coherent system of water-partings they had the orographical skeleton of the world? Having drawn the courses of the rivers, they had only to run caterpillar-shading along the water-partings to produce a map, in parts accidentally true, which represented the land as uniformly composed of a series of flat pans. Such a method of map-drawing was advocated by Friedrich Schultz, in a paper published at Weimar as late as 1803, and is not rare in popular maps of much later date.

It is to Alexander von Humboldt that we owe the method still in use for giving a general, yet real, idea of the relief of a little known country. Following, as he himself tells us, the precedent of the canal engineers, he constructed vertical sections along his routes through Spain and Mexico. It is worth noting in this connection that our knowledge of the relief of the sea-bed is mainly due to the requirements of another set of engineers—those engaged in laying telegraphic cables. Humboldt's sections were rendered possible by the daily use of the barometer and chronometer, and by Ramond's improvement of the formula for the reduction of barometric data. Before Humboldt, the barometer had been used for the determination of isolated heights, but not for the traversing of a whole country.

Turning now to the other basis of scientific geography—a knowledge of the fluid circulation in the outer envelopes of the earth—we may regard the corner-stone of climatology as laid by George Hadley in 1735, in his well-known paper before the Royal Society, 'Concerning the Cause of the General Trade Winds.'

All that was done before his time was mere digging for the foundations; yet with rare thoroughness he enunciated, at one effort, the final theory, detecting the cause both of the movement equatorwards and of the westward swerving. We can point to no such crucial utterance in the sister field of oceanography, though it is said that, about the time of the American Revolution, Benjamin Franklin suggested that wind-pressure was the cause of the surface-currents of the sea. His idea was contained in a memoir on the Gulf Stream, which was suppressed by him lest it should fall into the hands of the English, and be of use to their ships in crossing the Atlantic. Major Rennell also, who, by his map of India and his Herodotean identifications, presents a likeness to the best of the old school of geographers, showed his participation in the new by compiling an Atlantic current-chart. But Humboldt's invention of isotherms in 1817 first gave to climatology cartographic resources, and rendered easy and precise the correlation of climate with relief. The idea was soon applied in other departments of geography—to the expression of atmospheric pressure, of the temperature of the sea-surface, of density of population, and indeed to any similar masses of data, capable, so far as time is concerned, of reduction to averages, but varying locally. The last edition of Berghaus's Physical Atlas is, in this matter, a monument to the memory of Humboldt; yet it is strange that a method first suggested, in the seventeenth century, by the magnetic lines of the Englishman Halley, should have been left to fructify in the mind of a German of the nineteenth century.

The facts of geography are obviously capable of two kinds of treatment. The chapter-headings may be such as 'Rivers,' 'Mountains,' 'Cities,' or such as 'Ireland,' 'Italy,' 'Australia.' In other words, we may consider the phenomena of a given type in all parts of the globe, or we may discuss in a given part of the globe the phenomena of all types. In the former case, our book should *as a whole* observe the order of what has been called the geographical argument; in the latter case each chapter, the discussion of each country, should exhibit that order complete. For historical reasons, which will be referred to later, we English have fallen into a bad habit of describing the former treatment as 'physical geography,' and the latter as 'geography.' The Germans are more reasonable when they contrast *Allgemeine Erdkunde* with *Länderkunde*, but Chorography, our nearest English equivalent to *Länderkunde*, is a clumsy expression. An alternative would be to speak of 'special geography,' thereby implying a correlative to 'general geography,' which is a precise rendering of *Allgemeine Erdkunde*. By whatever name we call it, however, it is clear that the treatment by regions is a more thorough test of the logic of the geographical argument than is the treatment by types of phenomena. Hence Humboldt's *Essai politique sur la Nouvelle-Espagne*, published in 1809, must take high rank among the efforts of the new geography as the first complete description of a land with the aid of the modern methods. Here, for the first time, we have an exhaustive attempt to relate causally relief, climate, vegetation, fauna, and the various human activities.

The services of Humboldt to our science were so great that he almost merits the title of a new founder, and yet, of late, it has been the custom to decry him. It is probable that his memory has suffered a little from the less original work of his old age, for the Humboldt who devised cross-sections and isotherms, and wrote the *Essai politique*, was divided by the distance of a whole generation from him who was responsible for the *Asien* and the *Kosmos*.

We come now to the central event in the history of modern geography. It was in the year 1820 that Karl Ritter was called to Berlin to act in the double capacity of Professor in the Military School and Professor Extraordinary in the University. Born in 1779, ten years after Humboldt, Ritter's early training and circumstances were such as admirably to fit him for the great position he was to occupy during the last thirty-nine years of his life. His schooling was at Schnepfenthal, under Salzmann, a well-known educational experimenter of the following of Rousseau. Later in life Ritter learnt to know and to love the classics, but Salzmann's hostility to them as an educational implement secured for his pupil freedom from the current intellectual moulding. The peculiar opportunities of his subsequent position as tutor in the Hollweg family almost amounted to an endowment for research, and it was then that he accumulated that vast miscellaneous knowledge so valuable to the intellectual pioneer. It is not unimportant in connection with Ritter's later theories to observe that, at this time, Cuvier and Franz Bopp were applying the comparative method to anatomy and philology. Nor did he fail to cultivate that half-artistic perception of land-forms, the early exercise of which seems to be to the geographer what youthful training in pronunciation is to the linguist. While travelling with the young Hollwegs, he caused astonishment in Switzerland by the accuracy of his delineation of a mountain range. Add that fortune brought Humboldt and Pestalozzi across his path, and we understand the influences which shaped Karl Ritter into the greatest modern professor of geography.

Ritter produced both books and men. He had the personal charm of the born teacher, and the Prussian officers of 1866 and 1870 were as truly his intellectual offspring as was the *Erdkunde*, of which Schlegel said that it was the Bible of Geography. Nor did his classes fail to bring forth professed geographers, such as Guthe, and historians with the geographical eye, such as Curtius. But Ritter did not stand alone. He was one of a group of four men, who together made the geography of the nineteenth century as distinctively a German science as that of the eighteenth century had been French. One is almost tempted to draw a comparison, man for man, between Humboldt, Ritter, Berghaus, and Perthes, and that great group of later Germans—Bismarck, Moltke, von Roon, and William I. The coincidence is not quite so fortuitous as might at first sight appear; for Berghaus, the cartographer, and Perthes, the capitalist employer of cartographers, were as necessary to the earlier combination as, to the later, were von Roon, the organiser, and William, the kingly employer of statesmen and generals.

In 1827 Humboldt, who, on his mother's side, was French by descent, left Paris, which had been his home for nearly twenty years, to join the Prussian Court at Berlin. In the winter of 1827–28 he gave a course of brilliant lectures before the University, in which was contained the nucleus of the subsequent *Kosmos*. In 1829, at the invitation of the Russian Government, he spent twenty-five weeks on a rapid journey to the mines of the Ural and Altai, and received the impressions which led to the *Asien*. Thence onward Humboldt and Ritter lived at Berlin, mutually appreciative, and complementing each other in mental characteristics. They died in the same year, 1859, just before those great political events which changed the whole aspect of German life.

The influence of the new school was early felt beyond Germany. Petermann, the pupil of Berghaus, came to our islands to help Keith Johnston with the English edition of Berghaus's great Physical Atlas, whilst Arnold Guyot, the Swiss disciple of Ritter, after teaching for a time at Neuchâtel, crossed the Atlantic to lecture at Harvard, and afterwards to accept a chair at Princeton.

No sooner, however, were the two great masters at Berlin dead, than German geography passed into a new phase, a phase of which the typical representative was Oscar Peschel, the critic of both Humboldt and Ritter. The facts of Peschel's life are soon told. He began as a journalist, he became a geographical writer, and died a professor of geography. From 1849 to 1854 he was assistant editor of the Augsburg *Allgemeine Zeitung*. Then until 1870 he was sole editor of the weekly *Ausland*. From 1871 until his death in 1875 he occupied a chair in Leipzig University. The titles of his books may serve as an index to his mind. The 'Age of the Discoveries' appeared in 1858, and the 'History of Geography' in 1865. He then turned his attention to physical questions, and produced in 1870 his striking 'New Problems for Comparative Geography.' Finally, in 1874, came the *Völkerkunde*, a title not easily translatable into English. After his death his pupils, acting apparently under the inspiration of Professor Kirchhoff of Halle, collected his essays and lectures, which were published in a series of volumes edited with varying degrees of merit.

Peschel's criticism of Humboldt was of the rarest kind. He appreciated the good, detected the errors, and, above all, suggested the remedies. Humboldt's later works, the *Asien* and the *Kosmos*, both exhibit striking excellences, and for a time enjoyed great vogue, yet both, like Newton's Optics, helped to delay the advance of science. How this happened will be manifest if we reflect that general or physical geography is the basis, not only of special geography, but also of geology; and that just when Humboldt was vitiating his description of Asia with Elie de Beaumont's speculations on the origin of mountains, and was conveying the impression that general geography was equivalent to the entirety of natural science, Lyell was shaping physical geography to the ends of the geologist, and making it a key to unlock the past. The result, so far as geography is concerned, may be seen at the present day in the time-table of many an English girls' school. Separate hours are set apart for 'physical geography' and for 'geography.' The one is studied with a text-book written from the geological standpoint, the other in a manual of mere names lit up occasionally with a few ideas drawn from Ritter or Strabo. Thus it was that geography was divorced from physical geography to be unequally yoked with history. Peschel restored physical geography to the geographer, and made it the implement of analysis in the field of *Länderkunde*.

But while the geographers had gone astray in the wake of Humboldt, the geologists neglected that great chapter of their subject which they hold to-day in common with the geographers. Stratigraphy, palæontology, and mineralogy claimed their first attention, and it was only after a time that Ramsay and Geikie among the English geologists, and Dana among the Americans, began to study what we now call geomorphology—the causal description of the earth's present relief. It was Peschel who asserted the claim of geography to include geomorphology, and so rendered possible a genetic, as opposed to a merely conventional classification of the features of relief. Though common to both studies, it plays a different part in each. The geologist looks at the present that he may interpret the past; the geographer looks at the past that he may interpret the present. The geographer's argument begins, as we have said, with the surface of the earth, but to his almost artistic perception of land-forms he must add a causal analysis; precisely as the artist learns anatomy the better to grasp the human outlines.

Peschel's criticism of Ritter is less happy than that which he gave to Humboldt. He complains of Ritter's use of the expression 'Comparative Geography,' and substitutes another of his own. As a matter of fact, all geography which is not merely descriptive must be comparative, and the various uses of the term made by different writers are but particular cases of one of the most general ideas in scientific method. Varenius called all geography comparative that was not mathematical or astronomical. Ritter compared peoples with the lands they inhabited, in order to establish the influence of environment. Peschel compared one physical feature with another, with the object of discovering their origin. Markham uses comparative geography to imply a comparison of historical records, with a view to showing the changing aspects of the same locality at different times. Peschel's difference with Ritter is, in this matter, a merely verbal quibble. Nor can we say much more with reference to his obvious dislike of Ritter's teleological views, which, though they colour every statement he makes, yet do not affect the essence; it is easy to re-state each proposition in the most modern evolutionary terms. Where, however, Peschel questions the adequacy of particular correlations of peoples and environments, it must be admitted that he usually strikes between the joints, and this is still more evident when he has to deal with Ritter's daring follower, Buckle. The truth of the matter is that Ritter and Buckle had taken for their field the highest and most difficult chapter in geography, and that they underrated the complexity of the problems with which they had to deal. We are all familiar with the saying that it required the Greeks in Greece to develop the Athenian civilisation, and that neither the Greeks elsewhere, nor any other race in Greece, would have been equal to the achievement. It would be easy for a Peschel to demonstrate the falsity of an assertion that the Greeks owed all to Greece, but, on the other hand, the Ritters and Buckles were in error in attempting so simple an explanation. What seems to have been constantly omitted from these speculations is the fact that communities can move from one environment to another; that even a given environment alters from generation to generation; and that an existing community is often the product of two or more communities in past generations, each of them subject to a different environment. Now, the influences affecting a community at a given time may be resolved into dynamic and genetic. Among the dynamic influences, geographical environment is admittedly important. But the genetic influences are the momentum from the past, and the genetic influences acting on this generation may be resolved into the dynamic and genetic of the last. If this process be repeated through many generations, it is clear that the sum total of geographical influence is always accumulating. The Normans, for instance, were exposed to successive environments in Norway and in Normandy, and much that was out of place in Normandy was due to the earlier action of Norway. The American, again, has characteristics and institutions which could hardly have been cradled in the Mississippi plain, but are explainable by a reference to the peninsulas and islands of Europe. A very striking instance of the errors involved both in Ritter's methods and Peschel's criticismis to be found in the case of China. Peschel assumes that the Chinese civilisation grew up in China, and asserts that a land of so massive an outline was not fitted to stimulate such a growth. But the most modern research tends to show that the Chinese were not thus isolated in early times, and that Chinese civilisation was of Western, not home origin. Ritter erred in thinking the action simple and uniform, Peschel in underestimating its cumulative influence.

Since the war of 1870, geographical chairs have been multiplied throughout Europe, and especially in Germany, and at the present time German-speaking geographers form a little public of themselves. Some of the Professors, as von Richthofen of Berlin and Penck of Vienna, have worked mainly at geomorphology; others, such as Krümmel of Kiel, at oceanography; others, again, such as Ratzel of Leipzig, at anthropogeography; while Wagner of Göttingen has been conspicuous in cartography, and Kirchhoff of Halle and Lehmann of Münster in questions of method. Davis of Harvard and Woeikof of St. Petersburg may count as foreign adherents of the German school. There can be no doubt that it is especially in geomorphology that the advance has been most rapid, and here we may trace Peschel's impulse still unexhausted. In 1887 Gerland of Strasburg went so far as wholly to exclude the human element from geography, and to make it a purely physical science. He probably represents the extreme swing of the pendulum. There is evidence now of a reaction towards Ritter, and as Wagner has pointed out, we owe to Gerland himself the admirable series of maps in the new edition of Berghaus's Atlas, which deals with man, and brings out with startling clearness the interdependence of relief, climate, and population.

Let us now sum up the problems and methods of modern geography as they have resulted from the last five generations of work and criticism. Merely verbal definitions may be left to the dialectician, but there are two different modes of giving practical definition to a department of knowledge. It may be considered either as a discipline, or as a field of research. As a discipline, a subject requires rough definition for the purposes of organisation. It should exhibit a central idea or a consistent chain of argument. On the other hand, no theoretical considerations can hold the investigator within set bounds, though he is none the less practically limited by the nature of the arts of investigation to which he has served his apprenticeship. The chemist should manipulate the blowpipe, the physicist should be an expert mathematician, the historian should be skilful as a palæographer, and familiar with mediæval Latin. That subject is most legitimate which admits of either definition, which exhibits both a consistent argument and also characteristic arts. The researcher will then be the writer of the text-book, and while research is fertilised by suggestions born of teaching, teaching will be illuminated by the certainty within uncertainty which comes of first hand touch with facts. Geography satisfies both requirements; it has arts and an argument.

There are three correlated arts (all concerned chiefly with maps) which may be said to characterise geography—observation, cartography, and teaching. The observer obtains the material for the maps, which are constructed by the cartographer and interpreted by the teacher. It is almost needless to say that the map is here thought of as a subtle instrument of expression applicable to many orders of facts, and not the mere depository of names which still does duty in some of the most costly

English atlases. Speaking generally, and apart from exceptions, we have had in England good observers, poor cartographers, and teachers perhaps a shade worse than cartographers. As a result, no small part of the raw material of geography is English, while the expression and interpretation are German.

The geographical argument has already been sketched. The first chapter deals with geomorphology—the half artistic, half genetic consideration of the form of the lithosphere. The second chapter might be entitled geophysiology; it postulates a knowledge of geomorphology, and may be divided into two sections—oceanography and climatology. At the head of the third and last chapter, is the word 'biogeography,' the geography of organic communities and their environments. It has three sections—phytogeography, or the geography of plants; zoogeography, or the geography of animals; and anthropogeography, or the geography of men. This chapter postulates all that has preceded, and within the chapter itself each later section presupposes whatever has gone before. To each later section and chapter there is an appendix, dealing with the reaction of the newly-introduced element on the elements which have been considered earlier. Finally, there is a supplement to the whole volume, devoted to the history of geography, or the development of geographical concepts and nomenclature.

The anthropogeographer is in some sense the most typical and complete of geographers. His special department requires a knowledge of all the other departments. He must study geomorphology without becoming a geologist, geophysiology without becoming a physicist, biogeography without becoming a biologist. It has been recognised ever since the time of Strabo that geography culminates in the human element, but the difficulties in the way of precise thought in this branch of the subject are such that, while its claims have been constantly reasserted, the other branches have hitherto made greater progress. At all times each race exhibits a great variety of initiative, the product, in the main, of its past history. In each age certain elements of this initiative are selected for success, chiefly by geographical conditions. Sometimes human genius seems to set geographical limitations at defiance, and to introduce an incalculable element into every problem of anthropogeography. Yet, as we extend our survey over wider periods, the significance even of the most vigorous initiative is seen to diminish. Temporary effects contrary to Nature may be within human possibilities, but in the long run Nature reasserts her supremacy. Celt, Roman, and Teuton successively neglected the Alpine and the Pyrenean frontiers, but modern history has vindicated their power. Probably, when it is fully recognised that the methods of anthropogeography are essentially the same as those of physical geography, advance will become more rapid. The facts of human geography, like those of all other geography, are the resultant for the moment of the conflict of two elements, the dynamic and the genetic. Geographical advantages of past times permitted a distribution and a movement of men which, by inertia, still tend to maintain themselves even in the face of new geographical disadvantages. Economic or commercial geography should probably be regarded as the basal division of the treatment. The streams of commodities over the face of the earth, considered as an element in human environments, present many analogies to the currents of the ocean or the winds of the air. Strategical opportunities, also, have a constant action on communities, in the shape of tempting or threatening possibilities. Political geography becomes reasonable when the facts are regarded as the resultant in large measure, of genetic or historical elements, and of such dynamic elements as the economic and strategic.

This being our conception of geography, it seems not without interest to sketch our ideal geographer. He is a man of trained imagination, more especially with the power of visualising forms and movements in space of three dimensions—a power difficult of attainment, if we are to judge by the frequent use of telluria and models. He has an artistic appreciation of land forms, obtained, most probably, by pencil study in the field; he is able to depict such forms on the map, and to read them when depicted by others, as a musician can hear music when his eyes read a silent score; he can visualise the play and the conflict of the fluids over and around the solid forms; he can analyse an environment, the local resultant of world-wide systems; he can picture the movements of communities driven by their past history, stopped and diverted by the solid forms, conditioned in a thousand ways by the fluid circulations, acting and reacting on the communities around; he can even visualise the movement of ideas and of words as they are carried along the lines of least resistance. In his cartographic art he possesses an instrument of thought of no mean power. It may or may not be that we can think without words, but certain it is that maps can save the mind an infinitude of words. A map may convey at one glance a whole series of generalisations, and the comparison of two or more maps of the same region, showing severally rainfall, soil, relief, density of population, and other such data, will not only bring out causal relations, but also reveal errors of record; for maps may be both suggestive and critical. With his visualising imagination and his facile hand, our ideal geographer is well equipped, whether he devote himself to a branch of geography or to other fields of energy. As a cartographer he would produce scholarly and graphic maps; as a teacher he would make maps speak; as an historian or biologist he would insist on the independent study of environment instead of accepting the mere *obiter dicta* of the introductory chapters of histories and text-books; and as a merchant, soldier, or politician he would exhibit trained grasp and initiative when dealing with practical space-problems on the earth's surface. There are many Englishmen who possess naturally these or compensating powers, but England would be richer if more of such men, and others besides, had a real geographical training.

Let us consider for a moment the methods of organisation by which the German results have been produced. There are two systems of examination important to geography—the philosophical doctorate of the Universities, and the *facultas docendi* of the State. Candidates for the doctorate present three subjects, one major and two minor, selected according to the taste or requirements of the student. Young geographers usually present themselves in geography as major, and in history and geology as minor subjects. The State examination for the *facultas docendi* is of greater severity and of more general effect, in that every secondary teacher must hold the Government qualification in the subjects he teaches. As long ago as the time of Mr. Keltie's report, a single professor, Wagner of Göttingen, had examined in geography 200 candidates for the *facultas docendi*. It is a consequence of this system that at the last meeting of the *Deutsche Geographentag* there was an attendance of 500 members, *mostly specialist teachers of geography;* and, as a further consequence, there is a market for good maps in the German-speaking lands, whereas in England, reformers are constantly daunted by the fact that the public actually *prefers* the bad to the good. English specialists are almost invariably compelled to use German maps.

In most German Universities there is now a Geographical Institute, possessed of lecture-rooms and work-rooms, with appliances and collections; and the teaching combines lecture, seminar, cartographical exercise, written thesis, and field practice. At Vienna, for instance, there are two professors of geography in joint charge of an institute founded in 1885. The institute has a yearly subvention from the State, and in 1891 had a library of 2,400 volumes, the necessary globes and telluria, and an equipment of instruments for observation and cartography, besides 131 wall maps, 27 relief models, 135 diagrams, 370 typical views (*Characterbilder*), 1,200 photographs, 148 bound atlases, and about 5,000 separate maps. There were also a collection of rock-specimens, used more especially to convey the necessary geological ideas to the *Historiker* (who form a majority of the students), and a series of typical school-books and school atlases for the benefit of teachers. Professor Penck remarks that the neighbourhood of Vienna is in itself an admirable laboratory for every department of geography. It should be carefully noted that the University Institutes compete neither with geographical societies nor with public libraries, in that books and specimens of rare or unique character are excluded from the collections, which are solely for the use of the students of the institute.

In England geography has no appreciable position in degree-examinations; there are no examinations at all for the post of secondary teacher, nor is there anywhere in the land anything really comparable to the German

Geographical Institute. Since 1869 the Royal Geographical Society has made repeated efforts to alter the situation, and it would be an error not to recognise that we are on the upward gradient. The Society's policy has been embodied chiefly in four measures—the offer of medals to the great public schools; the appointment of an inspector to report on foreign geographical teaching; the foundation of lecturerships in the universities, and the institution of a system of training for explorers. After sixteen years of trial the medals were discontinued on the ground that they affected only a few schools, and even in those schools only a few pupils. Out of a total of 62 medals awarded, no fewer than 30 fell to two schools; a noteworthy fact, as indicating at once the power and the rarity of skilled and enthusiastic geographical teaching. The most significant result of Mr. Keltie's report, and of the exhibition of specimens collected by him and now deposited with the Teachers' Guild in Gower Street, has been a general improvement in school text-books and maps, as seen particularly in some of the better elementary schools and training colleges. The university lecturerships have been effective only at Oxford for a sufficient time to judge of results. There, a considerable class of historical students attend lectures in geography twice a week, but are not likely to give the time necessary for more thorough study without the stimulus of examination. None the less, students who have heard lectures are gradually spreading geographical ideas, and the mere existence of the lecturerships is a valuable admission that the study is one of University rank. The classes for explorers have been conspicuously successful, and are probably the best of their kind in the world. But here we are dealing with those arts of observation in which, as already remarked, Englishmen excel.

With the example of Germany before us, with partial success to encourage us, with the interest aroused by the recent Geographical Congress to aid us, and with the reorganisation of secondary teaching impending, is not this the ripe opportunity for another, and it may be final effort, to make geography effective in English education? I do not deny that there may be several good roads to success, but I cannot help feeling that our most immediate need is a certain amount of centralisation. This is so for two reasons. First, because we English geographers require, above all things, a tradition. We vary so widely in our views, and our examiners examine so differently, that teachers are at a loss whether to keep to the old methods or venture on the new. The old classical education still maintains its supremacy, mainly because through strong tradition it is workable without artificial syllabus; it is an organism rather than a machine. German geography, despite its modern growth, has a tradition, for Germans are all sons in geography of the ancestral group—Humboldt, Ritter, Berhaus, and Perthes. Secondly, we need a worthy object lesson, which is attainable under existing circumstances only by the concentration of funds, and by the co-operation of several leaders. For no single lecturer, such as the Universities at present maintain, can deal adequately with all aspects of geography. An historical or classical student listens to a dozen different teachers at Oxford or Cambridge. Berlin and Vienna have each of them two professors of geography, besides *Docenten.* Moreover, a German student may pass from university to university, and thus correct the limitations of his teachers. Yet nothing short of a considerable object lesson in England will bring general conviction as to the value and possibilities of geography. Nor need we fear that when centralisation has done its work, independent and local initiative will not vary the general tradition. Furthermore, the centralisation should not be complete. The work in progress at the Universities must not be abandoned. It will steadily gain importance in proportion as the central body does the work for which it is designed.

Clearly, if the policy of centralisation be agreed to, there is only one site for the central school. It must be in London, under the immediate inspiration of that Royal Geographical Society, whose past services to the cause would be a guarantee of support during the early efforts. But geographers must associate with themselves experts in education, if they are to avoid certain rocks which have knocked many a hole into the geographical projects of the past, and if public bodies and private individuals are to be moved to financial generosity. The beginning might be on a relatively small scale, but must not be too small for completeness. Theory, both on the scientific and historical sides, must be represented, and each of the three geographical arts. As regards observation nothing better could be asked than association with the admirable classes already existing. Cartography would be needed not only to supply the English map trade with an occasional Petermann, but especially that all serious students of the school might learn the ways of the geographical workshop. Teaching would naturally be associated with the various secondary and elementary training colleges. A certain number of university men might be tempted by the offer of a diploma to interpose a geographical year between the university and the master's desk; for head masters would probably be only too glad to give the teaching of geography into the hands of specialists, provided these were men of university culture, able to be of general service in school-work, and provided also there was adequate guarantee that they were experts. There would, in addition, be a system of evening classes for teachers and clerks, and thus, while the school would render obvious and direct service to six millions of people, the staff would gain strength from the sense of a generally diffused trust in them. The school would in no way duplicate the Geographical Society, while its staff would contribute an element of trained experts to the newly established afternoon meetings.

I launch this scheme, not with any fixed idea on the subject, for I would willingly abandon it in favour of another shown to be better, but because I am convinced that now is a great opportunity, and that a definite plan, even if it should prove unworkable, is more likely to provoke discussion and to produce result than mere negative criticism, which has often been anticipated. As effects of any adequate scheme, I should hope that, in a few years' time, geographical examinations would consistently test not merely memory for small detail, but clearness of apprehension, breadth of view, and power of statement, whether in word or map; that teachers would have the knowledge needed for Socratic rather than dogmatic teaching, and that students of geography would exercise the powers of analysis and composition, and not merely observe and remember. Geography would then be a subject rather for the higher than the lower parts of schools, and with the aid of a shelf of the classics of travel, sixth-form boys would write geographical essays with rapid but accurate map illustration. Then, the Universities would receive freshmen who, whether candidates for historical or scientific honours, could express themselves resourcefully in map and diagram, as well as in language and writing. I speak from experience when I say that not one undergraduate in thirty has the necessary equipment for accurate appreciation of space-relations in history, as well as time-relations. In an age of inevitable but unfortunate specialisation the organising of another correlating study should not be unwelcome.

Once more, let us emphasise the fact that geography is not the science of all things. It has been the aim of this address to bring out the specific character of geography and of the geographer. Nor is it the only important subject in education. Its devotees frequently do it harm by excessive claims. Moreover, let us admit that as geography is now too often taught, and even as it is conceived of in some circles which pass for geographical, it merits no greater mercy than it receives at the hands of educationalists. Nor let it be denied that some facts that we would see taught as geographical are already dealt with in other, and as we think, less advantageous connections. Lastly, let us beware of extolling the German example, which happens to be good in geography, to the degree of imputing inferiority to the whole system of English education. Let us do full justice to the position of our opponents, let us humbly benefit by their criticism, and then claim soberly, but with persistence, that a worthy geography is no pariah among intellectual disciplines. Amid the changes of organisation which are imminent, let us steadily maintain that the geographical is a distinct standpoint from which to view, to analyse, and to group the facts of existence, and as such entitled to rank with the theological or philosophical, the linguistic, the mathematical, the physical, and the historical standpoints. No intellectual education is complete which does not offer some real insight from each of these positions.

The following Papers were read :—

1. *On a Journey in Tarhuna and Gharian in Tripoli.* *By* H. Swainson Cowper, *F.S.A.*

This short excursion was made with the express purpose of investigating a series of megalithic ruins, which were known to exist, but of which nothing has been hitherto known, except brief notices on one or two sites mentioned in the writings of the travellers Barth and Von Bary. The author travelled first south-west, and entered the Tarhuna district by the Wadi Doga, which appears never to have been entered previously by an English traveller. The Wadi Doga is a fine valley about 800 feet above sea-level, surrounded by hills about 800 feet higher, and contains numerous ancient sites of megalithic temples, some in a fair state of preservation. Thence the author passed by Kasr Doga, a magnificent Roman monument described by Barth, on to the Tarhuna plateau, a grassy and partly cultivated plain, twenty-five miles from east to west and of unascertained width. Here the remains were even more numerous than in Wadi Doga, there being hardly a hillock on the summit of which the remains of one of these megalithic temples could not be found. Mr. Cowper camped on this plain with the family of his guide, and was throughout treated with hospitality by the Tarhuni Arabs. These people are pastoral Arabs of pure race, rigid Mussulmans, but apparently not fanatically inclined towards Christians. They live in rows of tents during the winter, and in wattle huts among their crops during summer. Some of them inhabit underground chambers dug in the soil below the level of the ground.

Leaving the Tarhuna plateau, the author rode north-east, and crossing the Wadi Daun (which with two smaller Wadis which join it are full of Roman ruins and crossed at frequent intervals by Roman dams) he reached the foot of Jebel Msid, lying at the east end of a wide and beautiful valley called Kseia. Having examined the ancient sites here, he retraced his steps to the Tarhuna plateau, which he crossed to the south-west, and entered a country of more mountainous character. These hills are partly in Tarhuna and partly in Gharian, and his route was crossed at frequent intervals by important watercourses running north towards the coast. The country, like the Tarhuna plateau, is nearly treeless, and in March very poorly supplied with water. A few crumbling ruins, probably of Roman date, cap the hills, but the megalithic sites are comparatively rare. Houses in Gharian are, as in Tarhuna, unknown, except at the Kasr, where there are Turkish troops.

Throughout the district game of any sort is most rare, nothing being seen except quails, partridges, a few hares, and a wild cat. After crossing the Wadis Bir el War and Gethathet Dum, the author arrived at Wadi el Ghan, a southern prolongation of the important Wadi Haera, which leads straight to Tripoli. The scenery down this Wadi is very fine, as it runs between grand cliffs of limestone and sandstone, and at one place there is a fine hill of ferruginous clay.

Emerging from the mountains, the author passed a curious isolated group of hills lying on the plain like islands, and from this point a two days' journey across the plain brought him to Tripoli.

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2. *On Rockall.* *By* Miller Christy.

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3. *On Western Siberia and the Siberian Railway.* *By* Dr. A. Markoff.

FRIDAY, SEPTEMBER 13.

The following Papers were read :—

1. *A Voyage to the Antarctic Sea.* *By* C. E. BORCHGREVINK.

More than half a century ago Sir James Clark Ross discovered the South Victoria Continent.

Nobody had visited those southern shores until last year, when the whaler 'Antarctic' forced her way through the ice-fields and ran into that large ice-free bay which stretches from Cape Adare down to the volcanoes Erebus and Terror. It seems strange that fifty-four years should have elapsed without any attempt having been made to finish that work which was so bravely commenced by an illustrious Briton. The more strange does this fact seem as the journals of the Erebus and the Terror tell about vast new and promising fields for science and commerce.

The recent antarctic expedition was a commercial one, and it was commercially a failure because we did not find the black or 'right' whale, so valuable for its whalebone.

The 'Antarctic' was fitted out for the hunt of that particular kind of whale, but I have nevertheless no doubt that the commercial result of the recent expedition would have been much better had we worked under more favourable auspices.

I by no means consider the fact of our not having met with 'right' whales in those seas as a proof of their not existing in the bay at South Victoria Land. It would seem to be incredible that Sir James Clark Ross made a mistake as to the existence of this valuable whale in southern latitudes.

Of great commercial importance are the guano beds which we discovered, and which ought to be well worth the attention of enterprising men of business.

From the analysis of specimens of rocks which I brought back from the mainland, the presence of valuable minerals on the continent is proved, although the lava flows and volcanic aspect of the coast-line do not speak favourably for the presence of heavy metals near the surface. The discovery of a brownish grey mica schist, evidently a very ancient sedimentary rock converted by heat and pressure operating through a long period of time into its present schistose and crystalline condition, together with the presence of 'granolite,' indicates the possibility of finding ore deposits, and is strongly in favour of a probable continuity of land from Victoria Land across the south pole to Graham Land. Somewhat similar schistose rocks are known to occur in the South Shetlands, south-east from Cape Horn.

The specimens from Possession Island are entirely composed of volcanic rocks. They are chiefly fragments of what seems to be a basaltic rock apparently belonging to flows of two different ages. The fragments belonging to the older flow show evidence of the lava having been much frothed up by steam escaping from its pores. It is of a reddish to pinkish brown tint. The newer lava is more dense and is of a blackish grey colour. It is, however, impossible to describe these rocks in detail until microscopic sections of them are completed.

An investigation of the origin and consequences of the north-east current which we experienced in the Victoria Bay is of great interest. When we look upon the phenomena which cause and accompany the great currents of the ocean in the northern hemisphere, we are justified in anticipating that also in the southern hemisphere similar phenomena occur.

The meteorology of the antarctic circle might throw a valuable light on the origin of oceanic currents; and it is not improbable that the warm current in the bay at Victoria Land plays a similar, if even an inferior, part in the southern hemisphere to that of the Gulf Stream in the northern.

The constant light pressure of the air within both the arctic and the antarctic circles seems remarkable. There is probably a similar movement from and towards the pole in the air as there is in the water, so that there is constantly a rush of cold air from the pole towards the equator, and this, combined with the slow movements of the globe, with its air so near the axis of rotation, would form the chief cause of this low pressure.

All through our voyage the westerly winds were predominant, but gradually decreased in strength as we drew south of the Roaring Forties. In noting the strength of winds, Sir James Ross's scale 0 to 12 was used. The strongest winds were noticed before we entered the antarctic circle, and not before we returned to the Forties again was wind of force 12 observed. We experienced then a very furious gale of distinctly cyclonic character, turning spirally from north-west to south, and reaching its maximum strength from the south. We had to use oil to protect the ship from the furious breakers. All the time spent in the bay at Victoria Land we experienced light southerly to south-easterly winds, and not once a wind of strength above 5. From the formation of the snow peaks I should think that the westerly winds prevail on the plateaux, and, should this be the case, a land expedition would be greatly assisted in returning from the south magnetic pole towards the bay by the use of sails on the sledges. Our heaviest snowfall was experienced just before we entered the icefields on our return. On the night of January 25, in latitude 69°, when the air was one dense white mass of snow, the wind being once up to 10 in strength, and surrounded by icebergs, our position was far from safe. Although the thermometer did not fall below 30° F., it was a cold and anxious watch in the crow's nest.

We always observed the reflection of the icefields in the air, and we were thus warned from far off, even of the presence of a narrow stream of ice or of an iceberg; this ice blink and the presence of the *Procellaria nivea* never deceived us. When the swell is heavy in the icepack, it is often very difficult to ascertain from which side the swell comes, and as difficult as this is, so is it important, for the safety of the ship depends upon a right judgment in these emergencies. When the huge ice masses begin to move and screw and press on the sides of the vessel, which rises and falls in the heavy swell, there is but one escape—namely, to work the vessel into the fields away from the side from which the gale blows.

Birds of the snipe family were discovered at the Campbell Island. Nests of the black-bellied storm-petrel were found on the rocks of Victoria Land, which is, therefore, the home of this hardy petrel. The white petrel, the *Procellaria nivea*, seemed also to nest at Cape Adare, where it lived in peace with the penguins. The penguins on Possession Island, and on the mainland, were all distinctly different from those seen at the Campbell Island.

The northern penguins, rock-hopper penguin (*Eudyptes saltator*), were all crested, that is to say, they had over each eye a tuft of long yellow feathers, which gives them an appearance of Mephistopheles in miniature, and their hoarse scream just suits their peculiar look.

The penguins which we met in the pack on Possession Island, and on the mainland, were the short-bellied penguin (*Eudyptes adeliæ*). Four specimens of *Aptenodytes Forsteri*, the large, lonely penguin, were secured. They had several pounds of pebbles in their stomachs.

It was noticed that the plumage of birds gradually changed into lighter colours as we drew southwards.

Four kinds of seals were seen—the white seal; the sea-leopard; the earless seal; and the common grey seal.

The difference in the formation of arctic and antarctic ice is known to be very great. While the northern bergs mostly consist of a large ice mass running up in numberless towers and arches resembling the very mountain peaks which surrounded the glaciers which gave rise to them, the antarctic bergs are solid masses of floating ice with perpendicular walls, and an unbroken plateau on the top.

All the bergs showed distinctly whether they were broken from the large southerly barrier, or were discharged from the glaciers of South Victoria Continent. All the barrier bergs had very distinct blue lines across their walls, indicating their annual growth by snowfall; these lines were, of course, not to be found on the glacier ice, which showed more likeness to the northern ice than did the former. The peaks and towers of the arctic icebergs are supposed to have been formed by the influence of ocean-currents wearing away the softer part of the ice mass under water until the natural action of gravitation causes them to upset. But why have the antarctic icebergs a different form, for there are great currents in the antarctic waters? And icebergs which have reached as far north as the south of New Zealand maintain this antarctic character. I can see no other reason for this dissimilarity between the bergs of the north and those of the south, but that the arctic icebergs as a rule must pass through climates which in temperature rapidly change from one extreme to another, and that they take much longer time in floating southwards than the antarctic icebergs do in moving northwards.

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2. *The Oceanography of the North Sea.* *By* H. N. Dickson, *F.R.S.E.*

This paper gives some account of recent physical work in the North Atlantic, the North Sea and the Baltic, in which the Swedish, German, Danish, Norwegian and British Governments have co-operated. The surface phenomena at different seasons are discussed, a special report on that section of the joint work having been drawn up by the author.

The importance of further research, especially in the interests of our fishing industries, is pointed out, and an international scheme, due to Professor Pettersson of Stockholm, described.

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3. *Oceanic Circulation.* *By* Dr. John Murray, *F.R.S.E.*

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4. *The Maps used by Herodotus.* *By* J. L. Myres, *M.A.*

The geographical digressions in the History of Herodotus are intended to supply the place of an atlas, and can be partially reinterpreted into pictorial form. That such pictorial maps were used, even before Herodotus's time, is clear from v. 49. Herodotus's descriptions are intentionally diagrammatic, and only give skeleton-outlines, on which the details are understood to be filled in. The general proportions are indicated, not by formal latitude and longitude (ascribed to Eratosthenes), but (1) by lists of places which are in the same straight line (ii. 34, iv. 181 ff.), and by columns of names which run up and down or across the map (iv. 37, v. 49), which is thus subdivided into rectangular areas (iv. 37, 99), or parallel strips (iv. 181); (2) by the presumption that a general symmetry is maintained in the distribution of land and water N. and S. of a natural 'equator' (ii. 26, 33; iii. 115; iv. 36, 37).

This 'equator' is indicated in two different real-latitudes in the different digressions, and these two 'equators' are associated with different principal N. and S. meridians.

Hence we may infer that Herodotus used two distinct maps based upon independent traditions and explorations, each best adapted to illustrate a different section—namely, the Greek and the Persian 'halves' of the known world—but not consistent with one another in the parts where they overlap.

A. The Ionian navigating-chart of the Mediterranean and Euxine: an early edition is used by Aristagoras of Miletos in v. 49. Its principal meridian lies through the mouth of the Nile, the Cilician Gates, Sinope, and the mouth of the Danube; its 'equator' is the line of the Royal Road, extended from Miletos on the Mæander to the ford of the Euphrates, produced westwards through the Pillars of Herakles, and eastwards (*a*) by Aristagoras, down the Choaspes conceived as flowing east, past Susa into the Eastern Ocean; (*b*) by Herodotus himself superimposed on the Pactyas equator of Map B.

B. The chart founded on Phœnician and other Oriental sources, and completed by Skylax of Karyanda, as a survey for Darius of the Persian empire. Principal meridian: a line of nationalities from the mouth of the Choaspes to the mouth of the Phasis (iv. 37) taken as parallel with the Euphrates-Tigris basin, and perhaps representing the meridian either of Susa or of Ecbatana. From this project westward two promontories—Asia Minor and Arabia—washed respectively on their outward sides by the Euxine and the 'Red Sea.' Arabia 'in theoretical geography leaves off' at the Isthmus of Suez, as Asia Minor does at the Dardanelles, but is 'practically found to be continuous' with Libya (iv. 39). Between the Peninsulæ lies the 'Mediterranean' Sea, with Cyprus in its axis (cf. v. 49); the Equator bisects the Mediterranean from the Pillars of Herakles, through Cyprus, to the Phœnician coast; thence (probably through Ecbatana) down the Pactyas river (perhaps the Ganges) into the Eastern Ocean. The southern coast line of Asia is determined by the voyage of Skylax (iv. 44); the northern is inferred thence by symmetry, and accommodated to the known Caspian (iv. 40).

The current controversy as to the frontiers of the continents refers also to these same maps (iv. 36, 39, 41, 45, 197), and to the map of Hecataeus (iv. 45), and is explained, together with the distortion of the eastern half of the known world, by the difficulty of apportioning a circular world among three traditionally equal continents, one of which, Libya, has since been determined to occupy only one quadrant of the circle, and to be bounded by the S. half meridian and the W. half equator, while the opposite quadrant remains still practically unknown.

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5. *On the Sixth International Geographical Congress, London*, 1895. *By* Major Leonard Darwin, *Sec. R.G.S.*

A short historical account of the Congress may be usefully included in the proceedings of the Section, so as to make them a complete record of the scientific year.

Five international geographical congresses have been held in various European centres during the last twenty-five years, but this is the first time that this international gathering has assembled in England. The Royal Geographical Society took the initiative in the matter of organisation, and the President of the Royal Geographical Society, Mr. Clements Markham, was, according to precedent, nominated President of the Congress, Mr. J. S. Keltie and Dr. H. R. Mill being appointed Secretaries. An exhibition was arranged in connection with the Congress which, whilst it entailed much labour on Mr. Ravenstein, Mr. Coles, and Mr. Thomson, who organised it, proved an attractive feature of the meeting.

The Congress was formally opened on the evening of Friday, July 26, by H.R.H. the Duke of York, one of the honorary presidents. On the following day the President delivered his opening address, in which he reviewed the present position of geographical science. In the afternoon two sections met. The question of surveying by photography was dealt with in one section, whilst in the other a very interesting discussion on education took place. Professor E. Levasseur discussed the French educational system, and pointed out the desirability of making geography less a matter of memory, which could only be done by making it embrace a wider area of thought. Dr. Lehmann and Mr. Herbertson advocated higher training for geographical teachers, the latter pointing out that instruction in geography in England in secondary schools was even in a worse position than in primary schools. Mr. H. J. Mackinder, in opening the discussion, showed that in England we are far behind both France and Germany in University and in secondary geographical training, and suggested the establishment of a geographical institute in London. Mr. H. Yule Oldham spoke in favour of the development of geography at Oxford and Cambridge. A small committee drafted the following resolution, which was afterwards adopted by the Congress: 'The attention of this International Congress having been drawn by the British members to the educational efforts being made by the British Geographical Societies, the Congress desires to express its hearty sympathy with such efforts, and to place on record its opinion that in every country provision should be made for higher education in geography, either in the Universities or otherwise.'

Monday, July 30, was devoted in great part to the polar regions. Dr. G.

Neumayer dwelt on the great scientific advantages of antarctic research, especially with regard to terrestrial magnetism. He urged international co-operation as the only means for securing adequate results. In the discussion which followed, he was supported by the great weight of the authority of Sir Joseph Hooker and Dr. John Murray, and a resolution advocating the necessity of antarctic exploration by an expedition before the close of the present century was unanimously passed by the Congress. Arctic travel was discussed, the first two papers being by Admiral A. H. Markham and General Greely. Herr S. A. Andrée's bold proposal to reach the north pole by means of a balloon attracted most attention. His scheme consists in filling a balloon at some convenient spot within the arctic circle, and then waiting for a favourable wind before setting forth. Experiments made by him have proved that, by the aid of drag ropes and sails, balloons can be made to deviate from the direction of the wind as much as 27° on an average, and he pointed out that the arctic regions were especially favourable for such operations because of the equable temperature, the absence of gales, and the nature of the surface of the ground.

The sections which met in the afternoon were concerned with physical geography and geodesy. Papers were read on the Modification of the Normandy Coasts, by M. S. Lennier, and on the Periodic Variations of French Glaciers, by Prince Roland Bonaparte. In the geodesy section, M. Charles Lallemand gave some account of the work of the French surveys, and papers were read by General J. T. Walker, Colonel Holdich, Mr. de Smidt, and Dr. Gill, on the geodetic work of the Indian and Cape of Good Hope Survey Departments.

On Tuesday the general meeting of the Congress was devoted to receiving reports on matters referred from the last Congress. The most important subject was Professor Penck's proposed map of the world. The report of the Commission was unanimously adopted by the Congress. It stated that the production of a map of the earth is exceedingly desirable; that a scale of 1 : 1,000,000 is especially suited for that purpose; and that the meridian of Greenwich and the metre be accepted for this map. The last statement is of peculiar importance in having the warm support of the French members of the Commission.

Professor Brückner presented a Report on a Scheme for an International Bibliography of Geography, and a resolution was passed, remitting to the Bureau of the Congress the study of this question. Mr. Frank Campbell read a paper, in which he proposed that each Government should annually issue a proper register of the literature of that country issued during the year in a form suitable to the requirements of bibliography; and a resolution dealing with this subject was passed—'That this Congress expresses its approval of the principle of State Printed Registration of Literature as the true foundation of National and International Bibliography, and approves the appointment of an International Committee to further the said object; the constitution of the committee to rest with the Bureau of the International Geographical Congress.'

The sectional meetings were devoted to oceanography and geographical orthography and definitions; and a resolution was passed—'That an International Committee be appointed to determine how far agreement can be arrived at as to the mode of writing foreign names.'

On Wednesday the question as to 'How far is tropical Africa suitable for development by white races?' was raised and produced a most interesting debate. Sir John Kirk commenced by reading a paper in which he distinguished between areas where true colonisation might be possible, and areas where white men might reside temporarily to superintend the labour of natives. After discussing fully the conditions necessary to render colonisation possible, he expressed the belief that there existed in tropical Africa considerable areas where the climate was such as to enable Europeans to become indigenous, and where the conditions as to health were probably not prohibitive, though on this latter point information was scanty. He believed that the experiment would be first tried in British South-East Africa, and also suggested Nyasaland as a possible field. A keen debate followed, in which Count Pfeil, Mr. H. M. Stanley, Mr. Ravenstein, Mr. Silva White, M. Lionel Decle, Major Baker, Captain Hinde, M. J. Vincent, Dr. Bassaria, Captain Amaral, Dr. Sambon, Dr. Murie and Mr. Louis took part. Slatin Pasha also gave an interesting account of his escape from the Sudan. Later in the day General Chapman read a paper on the Mapping of Africa, and a committee having been appointed to consider the question, the following resolutions were carried unanimously by the Congress at a later meeting:

'That it is desirable to bring to the notice of the Geographical Societies interested in Africa the advantages to be gained:—

(1) By the execution of accurate topographical surveys based on a sufficient triangulation of the districts in Africa suitable for colonisation by Europeans.
(2) By encouraging travellers to sketch areas rather than mere routes.
(3) By the formation and publication of a list of all the places in unsurveyed Africa, which have been accurately determined by astronomical observations, with explanations of the methods employed.
(4) By the accurate determination of the position of many of the most important places in unsurveyed Africa, for which operation the lines of telegraph already erected, or in course of erection, afford great facilities.'

Only one section met in the afternoon, at which Professor Pettersson's scheme for further international work in the North Sea was considered. A resolution to the following effect was passed by the Congress on its last day of meeting:

'That the Congress recognises the scientific and economic importance of the results of recent research in the Baltic, the North Sea, and the North Atlantic, especially with regard to fishing interests, and records its opinion that the survey of these areas should be continued and extended by the co-operation of the different nationalities concerned, on the lines of the scheme presented to the Congress by Professor Pettersson.'

On Thursday, Mr. C. E. Borchgrevink read an interesting paper, in which he described his antarctic voyage. Professor Kan then read a paper on New Guinea, and Mr. Lindsay discussed future exploration in Australia. One of the sectional meetings was devoted to cartography; Professor Elisée Reclus reading a paper on a proposed terrestrial globe on the scale of 1 : 100,000. In the other section, Dr. Naumann compared the fundamental lines of Anatolia and Central Asia, and Mr. Henry G. Bryant gave an account of observations on the most northern Eskimo, chiefly made during the Peary Relief Expedition.

Friday's papers were of interest mainly to specialists. The general session dealt chiefly with ancient maps, a paper by Baron Nordenskiöld being presented by the President, and a very valuable discussion of the origin of the sea-mile, given by Professor H. Wagner. The sections had papers on spelæology and mountain structure, and on the geographical nomenclature and the morphology of the earth, by Professor Penck.

On Saturday only one paper was read, by General Annenkoff, on the importance of geography in the present agricultural and economical crisis. A series of resolutions, drawn up by the various committees or submitted by private individuals, were put to the meeting. The President then delivered a short concluding address, and dissolved the Congress.

Experience had shown that if the Congress were divided into a large number of sections, papers would be brought forward dealing with points of detail, and larger questions, which alone ought to be considered on such an occasion, would not receive a proper amount of attention. The plan was therefore adopted of having a morning meeting of the whole Congress, and in the afternoon having only two sectional meetings. During the time when the Congress was being organised a limited number of subjects were especially selected as being suitable for treatment at great international gatherings, and a number of gentlemen were approached to ascertain whether they would be willing to read papers thereon. These special papers formed the basis of the work of the meeting.

A consultative body was appointed at the Congress consisting of all the acting Vice-Presidents, gentlemen nominated as representing all countries and as especially qualified to consider every geographical subject. This consultative body reported to the Congress its opinion with regard to every question about to be submitted to it, and this opinion carried so much weight that the views of the Vice-Presidents were in every case accepted by the Congress as a whole.

Another useful innovation is the resolution that the officers of each International Geographical Congress are to retain their duties until the meeting of the next Congress. The Congress only meets once in three or four years, and in the interval there has been no authority charged with the duty of seeing that the resolutions passed are carried out. Continuity of action is now secured.

The total number attending the Congress was about 1,500, of whom about 600 were foreigners, including most of the professors of geography in the world. The bringing together of so many workers in one science was, in all probability, one of the most beneficial effects of the Congress, and plenty of independent evidence could be brought forward to show how much our foreign guests appreciated our efforts to entertain them.

The Congress has never met in Germany, and it was decided that the next meeting should be held in Berlin in the year 1899.

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6. *On the Cosmosphere: an instrument combining the Terrestrial and Celestial Globes for the purpose of demonstrating Astronomical-Geographical Phenomena and Navigational Problems.* By W. B. BLAIKIE.

The cosmosphere is a form of globe in which the celestial sphere is a transparent film mounted with an independent motion outside the terrestrial sphere and concentric with it. The two spheres are connected with a floating horizon automatically adjusting itself to any latitude to be examined, thereby showing the student the actual apparent motions of the heavenly bodies from the standpoint of the observer; it also enables him, by measuring from the zenith and the horizon, to see and practise the problems in geodesy and navigation which have to be solved by travellers and navigators.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Papers and Report were read:—

1. *An Expedition to Ruwenzori.* By G. F. SCOTT ELLIOT, *M.A.*

The journey of which this is an account was undertaken with funds partly supplied by the Government Grant Committee of the Royal Society, and partly by myself.

The general route which I adopted was as follows:—

I left Mombasa in November 1893, and travelled up to Kampala, Uganda, by the ordinary route. I was unable to visit Elgon, and obliged to remain a month in Kampala on account of the war with Kabbarega which was then in progress. During this time Captain Gibb, Acting Administrator, entertained me with the very greatest kindness. After a month's delay, there seemed to be no chance of definite news from Unyoro, so I passed down through Buddu to the Kagera, which I was anxious to visit. I crossed this river at Kitangule and followed its course for six or seven days westwards. I then struck across Ankole to Ruwenzori.

After four months spent on the mountain, I turned southwards again, reaching the Kagera river at Latoma. I followed it as nearly as I could manage across Karagwe and then turned across Urundi and Bugufu towards Tanganyika, which

I reached in September. I came down Tanganyika in an Arab dhow, and afterwards crossed the Stevenson Road and arrived in the Shiré Highlands, eventually emerging from the continent at Chinde, the mouth of the Zambesi.

The earlier part of the journey was over very well known ground, and I shall therefore begin by trying to point out the relative position of Ruwenzori, which was the objective point of the expedition.

It rises in a very isolated fashion out of an area which is depressed relatively to the Victoria region plateau. The levels of the Albert Edward Nyanza and Semiliki Valley are both lower than that of the Victoria Nyanza, which is the lowest portion of the granite plateau usually called Uganda.

Ruwenzori is 16,500 feet in height. Dr. Gregory, in a paper to be published in the Journal of the Geological Society, has pointed out grounds for supposing that it is a 'scholl' mountain. The central core, of which I brought home a specimen, has been, in a sense, forced through the schists, which I found to dip away from it in all directions.

It is allowable to suppose that this process resulted in lines of crack or weakness. I found along what may be supposed to be lines of weakness of this kind a series of relatively recent volcanic craters and crater lakes. The most important is that which has produced the division of the Albert Edward into the Nyanza proper and Lake Ruisamba. The Salt Lake and four other craters belong to this line, which is approximately south-east. There is another running south-west, and along the eastern side one finds at least two others; one, at Vijongo, is in a north-easterly direction, whilst the other is nearly due east from Kyatwa and Butanuka.

These have all had the most important effect on the geography of the country round the mountain, but this cannot be clearly shown without a large-scale map. The recent volcanic area also extends across the Albert Edward and occupies a stretch of its eastern shore.

It seems strange that the mountain escaped notice so long, but it is obviously the 'Blue Mountains' of Sir S. Baker and the 'mountains of Usongora' which recur frequently in Emin Pasha's letters.

The reason is probably the way in which it is frequently covered with clouds. At about 10 A.M. thick clouds usually hang at an average level of 7,000 feet to 11,000 feet, though they are much lower in the narrower valleys. As the morning advances, they gradually ascend, and may vanish altogether at about 5.30 P.M. In fact, before 5.30 P.M., or occasionally just about sunrise, it is most unusual to see the summit except from a very great distance.

The vegetation follows the average movement of this cloud belt. From 5,000 to 7,000 feet the surface is covered by shrubs and cultivation. The true mountain forest begins at 7,000 feet, and extends to 8,600 feet. From 8,600 to 10,000 or 11,000 feet is a bamboo jungle; and from the latter level to 15,000 feet is a heather zone.

The forest is very dense, full of creepers, and with occasionally very fine timber. Sometimes it contains tree ferns, and is extremely similar to the wet forests of the Congo.

Mammal and birds are scarce. Bush buck may be seen occasionally, and there are *Cercopithecus* n. sp., *Colobus*, probably a new species, various squirrels, *Galago*, etc., but all are unusual. Butterflies also are particularly scarce.

The bamboo region is always extremely cold and wet, and climbing is excessively difficult and uncomfortable.

The ground in the heather region is mainly a wet and soft peat moss. Amongst this are masses of *Viola Abyssinica* (which I saw visited by a new species of Argynnis, *A. Elliotii Butler*), *Cerastium Africanum*, *Epilobium* sp., *Cardamine* sp., and *Hypericum*. There are extremely large-fruited kinds of Rubus, and, in the more sheltered ravines, enormous trees of *Ericinella Johnstonei*, as well as arborescent *Senecios*, *Hypericaceæ*, and the extraordinary tree Lobelia.

The mountain is in reality a meeting-place of floras.

The higher altitude plants are probably of Abyssinian origin, and have a very strong Mediterranean affinity. Those in many of the more humid and wet valleys at from 6,600 to 7,600 feet are of a distinctly Western type, while in the drier valleys below 5,000 feet one finds species of the Victoria regions, and above that level plants of Abyssinian affinity or belonging to the Ankole-Karagwe hills.

Besides all these sources, there are on this mountain many endemic forms.

The different races of mankind show a curious analogy to the flora.

The Wahima, which form the nobility of all the eastern side, are a very late immigration from Abyssinia.

On the western side the Wawamba are certainly very closely related to the Wanyuema tribes of the Upper Congo; while the Wakondja, in the centre of the mountain, which are part of the Bantu group (at least, so far as I could tell; I am not at all sure that they are not different), correspond to the plants of the Ankole and Karagwe hills.

The Wahima (*e.g.* such high chiefs as Kasagama and Makwenda, and the much less mixed villages at Kakaruka and Buhimba) are very distinct from the others. They have broad, prominent foreheads, small lips, and quite small and occasionally retreating chins. They are tall and slender in build, and amongst them may be seen occasionally individuals who have a very Semitic appearance. This race, coming from Abyssinia, seems to have overcome, and now furnishes the nobility of, all those tribes which border the Victoria. In the course of my journey I first met them in Kavirondo, and reached their westward limit on the borders of the Wawamba. Makowalli's people and all the tribes south of Latoma on the western side of the Kagera are not, I think, Wahima, and I do not fancy they ever crossed the Kagera below that point. In a southward direction I think they stop at Buhimba and Kakaruka; but beyond these places I did not go and cannot speak from personal experience. They are easily distinguished from the Bantu races by their extreme intelligence and disposition. They are treacherous, rather sulky, and also extremely licentious.

The Wakondja, who have been conquered by them, are greatly oppressed. I found them a simple, good-natured and industrious people of the regular negro type.

The Wawamba in manner, language, and custom, show distinct Wanyuema affinities. They are different physically from both the preceding races, but I found them so timid and suspicious that I was quite unable to obtain any exact measurements or learn the language. Unless the Wakondja contain amongst themselves remnants of a far more primitive race (and I should not be surprised to learn that this was the case), I do not believe there is an aboriginal people on Ruwenzori. The distinction I have drawn of three races on the mountain will, however, be found very marked.

During the four months which I spent on Ruwenzori I suffered greatly from fever; but I was able nevertheless to visit pretty thoroughly the Msonje, Yeria, Wimi, Mubuku, Sebwe and Nyamwamba valleys on the east, and the Butagu on the west. There are two important rivers on the south whose valleys I had not time to visit, and on the east the Muhokia and Hima were not investigated. I constantly attempted to reach the snow, but I never ascended higher than over 13,000 feet, which was in the Nyamwamba. I also nearly reached 13,000 feet on the Butagu. I did reach the summit of the range near the sources of the Yeria river on two occasions, but it was only about 11,000 feet at these places.

On my return journey I crossed to Kwa Kaihura and thence through Mpororo, Karagwe, Bugufu, Urundi to Tanganyika.

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2. *Report on the Climate of Tropical Africa.*—See Reports, p. 480.

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3. *Three Years' Travelling and War in the Congo Free State.* *By* Captain S. L. Hinde.

In 1891 Captain S. L. Hinde landed at Boma, and went up the caravan road to Stanley Pool. After four months' residence in the neighbourhood of the Pool, part of which was spent in exploring, he went up to the district of the Lualaba, and arriving there was immediately ordered to join an exploring expedition to Katanga. The force consisted of 350 regular soldiers, a Krupp gun, and porters. While on the road to Katanga they were attacked by Tippo Tib's slave raiders, under the command of his son Sefu. After the defeat of Sefu, a general rising of the Mahometans and the federation of all the branches of Arab slave traders of the Upper Congo and its tributaries occurred. The war which ensued resulted in the complete overthrow of the Arab slave trade in equatorial Africa west of Tanganyika. After the war Captain Hinde surveyed the unexplored parts of the Lualaba and Lukunga, between Kasongo and M'Bulli, connecting the surveys of Joseph Thomson with those of Stanley and his successors. In these regions the extreme fertility of the soil is noticeable. Owing to the intense heat, great moisture, and alluvial soil, all forms of vegetable life grow with an incredible rapidity. This vast tract of country is intersected by water ways navigable by steamers for some thousands of miles, and, as can be realised, might easily be exploited by Europeans.

As a result of the Arab overthrow, the traffic which formerly went down to Zanzibar from Nyangué and the Lualaba now follows the Congo to Stanley Pool and the Atlantic. The whole Congo basin must be specially adapted for coffee growing, as in every part of the forest wild coffee, of excellent quality, is abundant. While waiting for the coffee plantations to yield, rubber—which is found everywhere, and which only requires collecting—would be an important source of wealth.

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4. *The Progress of the Jackson-Harmsworth North Polar Expedition.* *By* ARTHUR MONTEFIORE, *F.G.S.*, *F.R.G.S.*

After dealing with the objects and methods of the expedition, Mr. Montefiore summarised the advantages of Franz Josef Land as the selected base under the following heads:—(1) Accessibility in any ordinary year; (2) northward prolongation of the land; (3) abundance of animal food; (4) the great importance of having a base on land; (5) the desirability of advancing into the unknown as far as possible by land; (6) the opportunity afforded by Franz Josef Land of erecting depôts until the 83rd parallel, at least, had been reached.

The second portion of the paper dealt with the progress of the expedition. Sailing from London on July 11, 1894, on board the 'Windward,' which had been purchased by Mr. Harmsworth for arctic work, the expedition arrived at Arkhangel, where it took on board extra supplies in the way of furs, provender, and Russian ponies, and whence it sailed on August 5. The ship next called at Habarova, on Yugorski Schar, for the Siberian dogs to be employed in sledging. From this point all definite information had, until a few days previously, ceased. But well credited tidings came from the walrus hunters in Barents Sea, stating that the 'Windward' had been sighted in the ice about the middle of August, and again towards the end of that month, steaming up an open lead.

The third portion of the paper described the events of the year which had come and gone since any news had been received. The arrival of the steam yacht 'Windward' at Vardo on September 10, 1895, had enabled the author to give the members of the British Association a short *résumé* of the doings of the expedition.

It appeared, then, that the 'Windward' safely made the south coast of Franz Josef Land on September 7; that on the 10th the heavy labour of discharging the cargo was begun; and that on the 12th the ship was frozen in for the winter. This, however, did not prevent the successful landing of the immense quantity of stores and general equipment, nor the erection of Russian loghouses, folding sheds, observatory, stables, kennels, &c.

During the winter, throughout which scientific observations were regularly made, Mr. Jackson and his colleagues shot no fewer than sixty polar bears for the sustenance of the party. Fresh meat was considered essential to their well-being and as a preventive of scurvy.

The sun returned February 23, 1895, and on March 10 Mr. Jackson began his northward journey. He made two double marches with sledges well laden and established a depôt 81° 20′ N. Returning to his base for more provisions, he found that the crew, who had wintered on the ship, had been attacked with scurvy. He did everything that could be done and got the ship under weigh on her homeward journey by July 3. When the ship left, Mr. Jackson was about to make a third march inland, and on this occasion he intended to utilise his boats.

The return journey of the 'Windward' was a marvellous instance of arctic navigation. For sixty-five days she battled with the heavy floe-ice, and, having consumed nearly all her coals, anything combustible on board was resorted to. The constant labour and exposure told heavily on the crew, whose behaviour was above praise. At last—with the loss of three men—she broke out of the ice on September 6, and safely made the port of Vardo on the 10th.

Thus it will be seen that all the expectations aroused on behalf of the expedition had, up to date, been fulfilled. Franz Josef Land had been successfully made; fresh food had been plentiful; the base was secure; advance northward had been easy and depôts were already in existence as far as 81° 20′; and, finally, the exploring party, with Mr. Jackson at their head, were in sound health and the best spirits.

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5. *The Struggle for Existence under Arctic Conditions. By* A. TREVOR BATTYE.

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6. *The Port of the Upper Nile in relation to the Highways of Foreign Trade. By* JAMES TURNBULL PLAYFAIR HEATLEY.

To introduce his paper and indicate its aim, Mr. Heatley cites the views of Sir Charles Wilson from his address at Bath in 1888 on the higher aims of the Science of Commercial Geography.

He proposes the introduction of the term 'nodality' for a commercial centre on a through line of trade, in accordance with a suggestion of Mr. Mackinder's in 1889.

He then discusses the relative merits of Alexandria, Sawākin (with Sheikh Barud), Massawa, Mombasa, Tanga, and Chinde, as ports with their respective trade routes, and states the case for Akik.

He shows that the Port of Akik is on the best bay of the Red Sea, and that a line of railway from Akik to Khartum by way of Goz Rejeb is the best route to bring Khartum and the Upper Nile into commercial relations with the maritime highways of trade. As the merits of different routes are decided by the importance of the nodalities which feed the highway of trade, he points out that the trade of the Habab and the Hagar districts will come to Akik. The important district of Tokar has been described as the granary of the Eastern Sudan, and is recognised as its key strategically. Here will also come the trade of the Beni Amr tribes from the valleys of the Anseba and the Baraka. At Filik there is the fertile district of the Gāsh. From Filik a line of some 50 miles to Kasāla will tap the provinces of Tākā, Gadārif, Galabat, and Senaar.

He points out that as soon as the line is made to Goz Rejeb, the Port of Akik is in direct communication with the Upper Nile from June to September, during which time the Atbara and the Nile at the Sixth Cataract are navigable.

From Akik to Goz Rejeb the distance is from 260 to 280 miles; the highest part of it is 1,650 feet, with easy grading and no difficulties. To Goz Rejeb as a nodality, where routes meet from all parts, the trade of the Upper Nile, of Darfur and Dongola, can come by ship and caravan. But the importance commercially and strategically of Khartum demands the line from Goz Rejeb, a distance of some 180 miles.

From Khartum the Nile, with some of its tributaries, is navigable for some 1,500 to 1,700 miles. The Blue Nile is navigable for 350 miles; the Sobat for 150 to 300 miles; the Bahr el Ghazal for 400 miles; the Bahr el Arab for 500 miles. The Nile itself—the Bahr el Abyad and the Bahr el Jebel—is navigable from Khartum to Kiri, a distance of 1,068 miles.

From Kiri, which is a fine district, and its Nile port, an important nodality, a line of some 50 miles to the mouth of the Unyama will bring the trade by ship from the lands in the basin of the Bahr el Jebel, the Victoria Nile, the Albert Lake, and the Albert Nile.

From the mouth of the Unyama a line will be made up the valley for some 50 miles to Fatiko, which is a fine district, and from Fatiko to Fauvera, some 70 to 80 miles, whence the Victoria Nile is navigable to Urondogani, some 160 to 180 miles.

Thus there is a feasible highway of trade from Usoga, Unyoro, and Uganda, and most of Kitara to Akik, as the Port of the Upper Nile.

7. *Exploration in the Japanese Alps*, 1891–94. *By the* Rev. WALTER WESTON, *M.A.*, *F.R.G.S.*

The two chief mountain systems of Japan, running north-east and south-west respectively, meet in the centre of Hondo (the main island). Here, where the country attains its greatest width, the peaks rise to the loftiest heights, and exhibit the grandest characteristics in the range of the 'Japanese Alps.' The distant view resembles that of the Sierra Nevada of Spain, to which these mountains correspond in latitude and elevation. The range rises from the Sea of Japan, about 37° N. latitude, and extends nearly 100 miles southwards, throwing off spurs east and west. Some of the highest peaks are volcanic, others are granite; or, as in the case of Yarigatake, the highest (10,500 feet), hard brecciated porphyry.

Owing to its position, the chain forms a barrier to the Siberian winds after their passage over the moist atmosphere of the Japan Sea, and causes an extraordinary snowfall in the winter, sometimes capable of burying whole villages, on the west side, whilst the east at the same time is comparatively free from snow.

No traces of glacial action have been found, but snow lies in summer as low as 7,000 feet in various places.

Remarkable solfataras are found on some of the volcanic peaks, notably on Tateyama, in the north.

At the foot of other mountains mineral springs (usually sulphur or chalybeate) attract the peasantry by their medicinal properties. In some of these baths people are said to stay for a month at a time, sitting with a heavy stone on the lap to prevent them from floating in their sleep.

Several remarkable silver and copper mines have been found on the west side of the range. Near Hirayu, at a height of 7,000 feet, work is carried on all the year round, the annual output of copper being said to reach 140,000 lb., and that of silver 2,500 lb.

The *flora* is remarkable both for variety and extent.

Alpine plants are found near the summits, whilst lower down the flanks of the chain show many English wild flowers side by side with our favourite ornamental plants, in addition to others which are quite strangers to us.

Magnificent lilies (*auratum*, *tigrinum*, &c.), Lychnis grandiflora, Hydrangeas, Iris, &c., give gorgeous colouring to the lower slopes. Stately cypress forests abound, and on the west side the Japanese yew, celebrated for the beauty of its red-grained timber, is found, usually, however, as a scattered shrub. The mulberry tree is extensively grown on the east and west sides, the silkworm culture being a very widespread industry.

The *fauna* includes black bears, boars, chamois, badgers, hares (which turn white in winter), flying squirrels, &c.

The writer has also met with the golden eagle, ptarmigan, black-and-white crow, and a nightingale with a very sweet full note.

The giant salamander has occasionally been found, especially in the south-west of the range.

The clear mountain streams abound in trout.

Although travel in these wild regions is very rough, still the people dwelling on the outskirts of the main chain are kind, polite, and hospitable to a degree. Many of their customs and superstitions are very curious. They hold a strong belief in the power of foxes, badgers, wasps, &c., to 'possess' human beings, of which the writer has had odd personal experiences.

In times of drought strange ceremonies, sometimes accompanied by sacrifices, are performed on some of the mountain tops with the object of obtaining rain.

Ontake, an extinct volcano to the south of the range, 10,000 feet high, is, next to Fujisan, the loftiest sacred mountain in Japan. Pilgrims visit it every summer to practise a sort of hypnotic trance called *kami-oroshi*, or 'bringing down the gods.' Through the intervention of a skilled 'medium' communication is said to be held with the spirits of departed heroes, &c. Oracular replies are given to questions dealing with the prospects of future health, business, weather, &c. It is a fast dying-out survival of a curious Far Eastern presentment of the Delphic Oracle.

TUESDAY, SEPTEMBER 17.

The following Report and Papers were read :—

1. *Report on Explorations in South Arabia.* See Reports, p. 491.

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2. *Formosa.* *By* JOHN DODD.

This paper gives an account of observations and explorations in the island of Formosa made by the author during his residence there from 1864 to 1890. After referring to the work of British naval officers, consular officers, commissioners of Chinese customs, and others, and giving a general geographical description of the island and its commerce, the paper goes on to discuss the probable origin of the aboriginal tribes occupying the highest mountain districts. The mode of life of the savage inhabitants is described—their dress, weapons, methods of hunting, marriage customs, &c.—and special reference is made to the practice of head-hunting, whether indulged in from motives of revenge or as a pastime merely. The paper next deals with the Pepawhano, or descendants of the savages of the plains, their spoliation by Chinese immigrants, and the work of the Dutch missionaries amongst them. In the concluding section the author refers to the colonisation of parts of Formosa by immigrants from Fokien, and to the Hakka invasion of the hill districts. Some account is given of the opening up of foreign trade, especially in camphor, coal, and tea, and an estimate is formed of the commercial resources of Formosa and of the prospects of their development.

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3. *Russian Possessions in Central Asia.* *By* DR. A. MARKOFF.

A comprehensive survey of Russia's Central Asian possessions is a task of great difficulty for anyone who is not a Russian, on account of the Russian language. An attempt is here made to give reliable data for a geographical description of this part of the world, where the three largest empires meet.

The Russian possessions are: (1) The Transcaspian district, parcelled up into the provinces of Manghishlak, Krasnovodsk, Askhabad, Tejen, Merv; (2) Turkestan with Samarkand, Syr Darya, and Fergana; (3) the Khanat of Khiva; and (4) Bokhara.

The author described the different districts and their boundaries; the population, Russian, Persian, Tartar, Armenian, and others; industries, such as fishing, agriculture, gardening, the cultivation of silk, cotton, and grapes; stock-breeding, mining, and commerce.

The soil and climatic conditions of Turkestan were described. Turkestan is gradually losing its vegetation and drying up. Great changes in Russian commerce have taken place under the Minister of Finance, de Witte. Railways being acquired by the State, all freights and traffic rates generally reduced. Means of communication are increased and improved. Prospects for English trade in Central Asia and Russia were discussed. English-made goods enjoy a reputation in Russia of being superior to those of French and German manufacturers. English commerce has not hitherto had a fair share of the plums in Russia's commercial pie. No reason to be seen why English houses should not share in the markets where French and German commerce finds such ready outlets.

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4. *The Towns of Northern Mongolia.* *By* Dr. A. Markoff.

Mongolia, and especially its inner life, have hitherto not been properly studied. Travellers mostly confine themselves to noting only that which strikes the eye.

I. *Urga and its monasteries,* divided into three parts, are described; (1) the monastery, (2) Gandan (temples and residence of Buddhist students), and (3) Maimachen (merchants town). Bogdo Ula, the 'holy mountain,' stands to the south of Urga. The author described the Mongol veneration for the 'holy mountain'; no capital punishment is allowed to take place within sight of it; it is the reputed birthplace of Chinghiz Khan, to whom yearly sacrifice is made at the foot of the mountain. The author mentioned the piety of the Mongols and their belief that gifts to monasteries secure reward in after life. Richness of monasteries is a consequence of this belief. Description of temples: (1) The Duchin golobyin Sume; its gold cupola hung with innumerable silver bells, which are always ringing. It is inaccessible to non-Buddhists. (2) The Barun örgö (chapel of Abalai Khan), less a temple than a museum, with its ancient relics, including an old throne with figures thereon representing former Mongol heroes. (3) The Maidari temple, largest of all, which, besides its great idol, contains idols of 10,000 Buddhas made in 1799. Description of Urga market-place and its trade; the insanitary condition of the streets, the insupportable dust in summer, the ineffectual canal system for watering the streets; the Chinese quarters, their houses, occupations, and the immorality of the inhabitants.

II. *Ulejasutai,* second largest town in North Mongolia and seat of Government-General. Soldiers main population; tradesmen all Chinese. Labourer's hire 7*l.* per annum, including food but not clothing. Very picturesque neighbourhood.

III. *Kobdo.* Description of prison; cruel treatment of prisoners; minor offenders allowed to walk into town occasionally, when they have a board affixed to them to show they are prisoners. Town remarkable for cleanliness. Trade is in the hands of Chinese.

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5. *Notes on the Topography of Caria.* *By* W. R. Paton *and* J. L. Myres.

A series of short journeys in the neighbourhood of Mylasa, Keramos and Halikarnassos result in a number of corrections of the physical features: especially a considerable extension N.W. of the basin of the Kartal déré, which issues at Keramos; it has a common watershed with the China Chai, which joins the Mæander near Aidin.

The geology of the district determines its physical feature; the limestone plateau is drained partly by swallow-holes from enclosed basins, partly by deep ravines; beneath the limestone crystalline rocks are upheaved in two parallel N.W.–S.E. anticlinals, one forming the range of Latmos, the other extending from the root of the peninsula of Knidos, through that of Myndos, and as far as Patmos. About Myndos and in Kos was a volcanic area, active both before and after the deposition of the cretaceous limestones.

Remains of ancient Carian and Lelegian civilisation have been examined, and the following ancient sites have been identified and verified:—Pedasa, one at Karajahissar, one near Bitès (Ghiuk Chalar); Kindya at Utch-bounar; Telmessos, two towns and the oracular temple on the Kara Dagh; Karyanda at Ghiöl; Termile at Tremil; Pelea at Borghaz; Taramptos at Taranda.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

PRESIDENT OF THE SECTION—L. L. PRICE, M.A., F.S.S.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

AT the Oxford meeting of the British Association a report was presented on the 'Methods of Economic Training in this and other Countries,'[1] the general conclusion of which pointed to a deficiency in this country in the organisation of instruction and the recognition given by the examinations of the Universities, of the public service, and the legal profession. In the spring of the present year Mr. Goschen, presiding at a dinner of the Economic Association, commented[2] on the inopportune contempt of the practical man for economic reasoning at a time when many of the questions engaging public attention were economic in character. The phenomena thus noted may be connected, and a disregard of economic reasoning explained by a lack of systematic economic instruction. At any rate, the members of this Section will scarcely feel more certain of the fact that the questions of the day are largely economic in character than of the illumination obtained by an acquaintance with Economic Science and Statistics. They may not succeed in winning the attention of the practical man, but they are not unlikely to find solace in the flattering conviction that the loss is on his side, and not on their own. The proceedings of the Section in this and in previous years will prove beyond dispute that, whether or not the practical man troubles himself to ascertain or to follow the opinion of the professors, the professors are not seldom busy in the consideration of the practical questions of the day.

I make this assertion with the more boldness because it requires no extraordinary keenness of vision to detect signs in the practical man of a disposition hardly consistent with the scorn he is prone to bestow. I believe that, in spite of what we may regard as his worse impulses, he manifests a growing inclination to seek counsel—and even imperatively to demand guidance—on social and political problems from economic professors. I do not know how otherwise to explain the fact that a well-known firm of London publishers has issued, and, I imagine, found it profitable to issue, a series of books on social subjects which now numbers upwards of eighty volumes. Many of these books may not be scientific in character, but so large an issue, taken in conjunction with other significant circumstances, such as the recent revival of a desire for economic lectures on the part of the clients of University Extension, does afford some presumption in favour of a fresh growth of popular interest. Indeed, I have heard more than one practical man complain, not that it was unreasonable to look for guidance in economic matters from economic experts, but that, with every disposition to hear the advice of professors, it was impossible to obtain it. This complaint may or may not be founded on reality; but the professors may be pardoned

[1] See *Report of the British Association* for 1894.
[2] See *Economic Journal* for June 1895, vol. v. No. 18, p. 301.

if they regard it as a sign of a more wholesome condition of mind. The complaint may be due to the fact that the guidance sought is not such as the professors can offer, and that the advice, which they are able and ready to give, is considered inadequate or superfluous.

I am going to address myself to the audacious task of endeavouring to indicate by actual example the guidance which the economic professor may furnish to the practical man on the questions of the day; and I have prefaced my attempt with these observations to show that I am aware of the hazard and difficulty attendant. Were I to seek for an appropriate metaphor to describe my venture, I might find it by saying that I was about to disturb a hornets' nest; and, if I am fortunate enough to escape with the scornful neglect of the practical man, I am afraid that the professor may be less compassionate, and that his sting may prove as venomous. I may, perhaps, plead in excuse that it is at once the traditional privilege and the inherited duty of occupants of presidential chairs to devote their observations especially to that part of their science with which they have been most closely connected. I have certainly endeavoured on the one hand to bestow a considerable portion of my time on the scientific study of economics as expounded in systematic treatises, and, on the other, my occupation as College Treasurer has forced me into intimate contact with the hard facts of at least one department of practical life. I would not for one moment claim that this dual experience gives me any title to speak with authority on the relations of economic science to practical affairs; but it has determined the grooves in which my thoughts have mainly run, and, so far as I may presume to a special acquaintance with any department of economic speculation, it is with that which concerns the bearing of theory on practice. Without unbecoming arrogance, I may, perhaps, think that I possess in not very disproportionate measure the failings of the practical man and the academic professor; and in this capacity I undertake the task before me.

Before considering some particular questions of the day we may determine the general character of the guidance offered by economics in matters of practice. I believe that in this connection economists must disclaim a pretension to strict neutrality. Much, no doubt, may be urged in support of the claim, and considerable advantages might follow from its successful establishment. The cool examination of heated questions in the dry light of science might seem the appropriate occupation of the academic professor. From the serene heights of tranquil speculation he might complacently look down on the heat and turmoil of affairs, and, standing apart from the conflict himself, refuse to assist any combatant. But the strict maintenance of this attitude is a 'counsel of perfection' and a practical impossibility. The student must be more or less than human who, dealing with a department of knowledge so intimately related to the welfare of humanity, can avoid, as the result of his scientific inquiry, forming a favourable view of one course of conduct and an adverse opinion of another, and endeavouring to promote the former, and to hinder the latter, both by advice and by act. He cannot be content to observe the connection of cause and effect without trying to set in motion the cause or to restrain its action. He cannot acquiesce in the speculative solution of a problem without being impelled to embody his theory in practice. He cannot contemplate the misery due to bad economic arrangements without seeking to devise and apply a remedy; and, viewing the matter historically, the practical object of benefiting their fellow-creatures has been at least as powerful a motive with great economic thinkers as the speculative aim of enlarging the boundaries of knowledge. They have been reproached for hardness of heart and dulness of imagination, and the popular account is prone to regard them as dry and unfeeling; but the description is a travesty of the facts, and their errors have probably been due as often to excess as to lack of enthusiasm. The recurring contrast of wealth and poverty, of careless ease and careworn want, of lavish indulgence and narrow penury, has awakened as responsive a chord in their hearts as in that of the most ardent and generous socialist; and it is impossible to run over the conspicuous names on the roll of economic worthies without being impressed by the warmth of their zeal for social reform, and the intensity and persistence of their anxiety to remove or mitigate human suffering. The 'economic man' of popular description, whether or not he occupy a place in economic theory, is no portrait of the economist of actual historical fact. The name of 'dismal science,' so often misapplied, was suggested not so much by the suppression of human interest as by the apparent destruction of cherished hopes. The science was 'dismal,' not, as popular usage interprets the phrase, because it was dry and uninteresting, but because it seemed to counsel despair; and even then the title partook of caricature.

Nor do I think that in this connection an attitude of strict neutrality is desirable, if it be possible. The besetting sin of the academic temper is indecision, and few errors are more mischievous in practical affairs. An obstinate regard for neutrality may easily beget indecision, and from that moment the economist becomes ineffectual for practice. I must confess to the belief that the practical man has a right to demand an opinion on economic points from the academic professor, and that the professor has a claim to take part in the guidance of economic affairs which is derived from his scientific study. He is an expert, and it is no less his duty than his privilege to discharge an expert's functions. He cannot, as it seems to me, properly evade the one or abnegate the other. He may be careful in forming his judgment. He may conscientiously endeavour to assign its due weight to every circumstance. He may remember and insist that in many practical problems other aspects besides the economic must be considered. But the economic is often of great, and sometimes of paramount, importance; and on this he cannot disown the responsibility of making up his mind without, as it seems to me, forfeiting his own self-respect and his usefulness to others. From that moment his neutrality vanishes. He may, and probably will, incur an opprobrium which he might have avoided by a refusal to adopt a decisive opinion. He may sacrifice a quiet and ease which he might have retained. But, whether our aim be the correct conduct of affairs or the due recognition of economic science, I cannot doubt that he has chosen the better part. To insist on a strict neutrality for economists in matters of practice seems to me idle and misleading. It is idle, because the economist is human, and economics is concerned with some of the most important interests of human welfare. It is misleading, because it is the duty of the economic expert to offer guidance on economic points, and there are at all times few practical questions which do not present an economic side. Certainly at the present juncture, when the pressing problems of the hour are in many cases distinctly and admittedly economic in character, to attempt a divorce between theory and practice is especially inopportune. It is an impossible endeavour to saw a man into separate quantities; and I would claim for the appropriate description of every great economist the epitaph on the tomb of the German socialist, 'Ferdinand Lassalle, thinker and fighter.' We need not abandon the thought, but it should stimulate, and not paralyse, the action; for the one is not fully complete until it is realised in the other. Economics is indeed a science, and on that ground claims a recognised place in the programme of this Association; but it is essentially, as I think, an applied, and not a pure, science, and the economist has only fulfilled part of his mission when he has solved a speculative problem. I am aware that this contention may not be admitted by many academic professors and practical men, but I believe that it is in accord with historical tradition, and admits of logical justification.

Yet, if an attitude of strict neutrality be impossible and ineffective, the opposite extreme of dogmatic assertion is as undesirable as it is dangerous. The older economists have been often charged with an error of this nature; and it cannot be denied that the accusation rests on a basis of truth, though it has sometimes been couched in exaggerated form. Certainly the modern economist is inclined to state his opinion with less assurance; and for that very reason he has lost some of his influence on practical affairs. For the practical man has a sneaking affection, and even respect, for dogmatic assertion. At any rate, he desires a plain, direct, and concise answer to his questions, and it is not easy to distinguish between an avoidance of dogmatism and an appearance of indecision. Nor can it be denied that, as a discipline of the mind, a study of the more abstract reasonings of some of the older writers, which generally presented the semblance, and sometimes offered the reality, of a precise, defined, consistent whole, is both wholesome and stimulating. Legal authorities now pronounce inadequate Austin's 'Lectures on Jurisprudence,' but I must confess that I look back to my first acquaintance with them as an epoch in my mental history. I believe that they acted as a tonic and purgative, clearing away obscurity and stimulating intellectual effort. If I may say so, the effect of reading such an author as James Mill is not unlikely to be similar in the case of the young economic student; and for that reason, were there no other, I should personally regret the exclusion from a systematic economic course of the study of some of the more rigidly abstract reasonings of some of the more strict of the older economists. Such study may be regarded as a propædeutic, through which the student should pass; and he will lose, and not gain, by its omission. The regimen may be somewhat severe, and the diet, so far as the moment is concerned, not very nutritious; but the system is braced and the digestion strengthened.

The fact, however, is that the more famous of the older economists were themselves less abstract and precise than they are represented in common opinion. They took a keen and constant interest in the practical questions of their time. Their speculative opinions were largely influenced by the prominent facts of their day. The acumen of later, and even contemporary, criticism has discovered gaps in some of their reasonings and inconsistencies—which perhaps do them honour—in some of their arguments. Recent economic analysis certainly endeavours to bring within its range a larger number of facts, to be more explicit in stating and repeating the assumptions on which it proceeds, and to be more cautious in establishing conclusions and definite in limiting their application. But the change is largely due to the increasing complexity of the facts; and the difference in the mode of approaching and method of handling a question is one of degree rather than kind. The particular problems which confronted the older writers admitted more often of a plain dogmatic answer; and, if the deliberations of the later economist be more comprehensive and protracted, his conclusions need not on that account be indecisive. Indeed, with the lapse of time, the necessity and advantage of expert advice have grown more obvious and urgent.

What, then, is the general character of that advice? The answer may seem a truism, but it is surely this. As in other departments of study, the mission of the scientific economist is to discern, and to assist others to recognise, the unseen. He is not content with a superficial view. He endeavours to penetrate below the surface of affairs and discover the invisible forces. He employs telescope and microscope to bring within the range of vision what is distant or unnoticed. He compels the practical man to pay attention to something more than the obvious and immediate consequences of the policy he is pursuing; and the chief advantage of economics as part of a scheme of general education seems to consist in inducing a habit of mind which will not be satisfied with superficial explanation. And it induces this habit in matters with which men and women are brought into close and necessary contact in the ordinary routine of everyday life. They may flatter themselves that common-sense alone is needed to deal with such matters, and that no scientific training or aid is required. Economics dispels this subtle and dangerous illusion, and furnishes an instrument which at once controls and strengthens common-sense. Nor is this claim for economics as a discipline of the mind and as a guide in matters of practical conduct by any means novel. It was put forward with prominence by Bastiat, whose writing is sometimes regarded as an illustrative example of the application of orthodox economics to the treatment of an important practical question. It has been recently adduced by the Duke of Argyll, who, dissatisfied with what he considers orthodox economics, attempts to supply its defects by disclosing the 'Unseen Foundations of Society.' The arguments and conclusions of Bastiat may not be accepted, the criticisms of the Duke may be refuted, by contemporary economists, who may claim the title of orthodox, if they desire an epithet which seems to bring as much opprobrium as honour; but they would certainly agree with the earlier exponent and the later critic, who, curiously enough, have not a little else in common, in regarding the mission of economics as an endeavour to see, and to reveal to others, the unseen.

That such a description is no barren truism, that economics thus conceived may shed illumination on dark or obscured problems, that it may prove, in Bacon's language, not merely *lucifera*, but also *fructifera*, may, I think, be shown by a brief consideration of some typical questions of the day.

I. Few are more prominent than that of industrial strife. We deplore its occurrence, and are ready to welcome any promising means suggested for mitigation or prevention. Nor does popular opinion refuse to economics a voice in the matter; but, on the contrary, its authority is continually invoked. What, then, in accordance with the principles we have sought to establish, is the guidance which it can offer? Are there any common beliefs which it may show to be superficially founded? Few assertions certainly are more frequent than that the interests of employers and employed are harmonious, and that disputes involve a disturbance of this fundamental harmony. On the other hand, few facts are more obvious than that employer and employed regard their interests as essentially antagonistic, and from this antagonism the disputes have arisen. Economics is able to show that either view expresses a portion, and only a portion, of the truth; and, by the systematic mould in which its reasoning is cast, it brings into clear relief the relation of the complementary truths.

In the production of wealth the interests of the parties harmonise, for, with the modern organisation of industry they require the services of one another, and, the more efficient they respectively are, the larger is likely to be the wealth produced. It is the interest of the employer that the wages earned by the men should be adequate to maintain, and, if possible, to increase, their efficiency; and it is the interest of the employed that the profits of the *entrepreneur* should encourage enterprise and induce a sufficient supply of capital. For production—and this is a point which economics, and economics alone, can duly emphasise—is the ultimate source of the wealth distributed. The larger the amount produced, the larger, *cæteris paribus*, is likely to be the share of either party in distribution; and in any event it is certain that a decreased production must issue in effects on distribution, the burden of which will fall, though in varying measure, on either party. The influence thus exerted on distribution by production is one which workmen seem especially likely to forget, and many of the common arguments in favour of 'making work,' or providing 'employment for the unemployed,' proceed from ignorance or neglect of this consideration.

On the other hand, it may be urged that employers are not very keen to recognise the influence, whether for advantage or drawback, of distribution on production. No doubt the division of economics into separate departments tends to make even the student forget their mutual connection. We do not remember constantly that production and distribution are simultaneous, and are only distinguished for purposes of convenient analysis. Yet one of the most important advances of recent economics consists in the emphasis given to the influence of distribution on production; and we see more clearly than our predecessors how the poverty of the poor, by begetting inefficiency, may cause their poverty, and high wages may imply, not a high, but a low, cost of production. Either of these truths may be pushed to excess; but they are certainly fraught with important consequences, and have an intimate bearing on the question before us. But, like the influence of production on distribution, the telescope of the economist is needed to bring and retain them within the range of ordinary vision.

The full and constant recognition of these truths conduces to a more comprehensive conception of the possible results of industrial disputes. We can see, on the one hand, that a victory for the moment may not prevent defeat in the long run, and that loss, which is obvious at the time, may issue in ultimate gain. When we remember that to discern these distant results the naked eye of the plain observer seems incompetent without the aid of the economic organon, we are as ready to recognise the likelihood of industrial conflict as we are anxious to devise the means of preventing it. For in the distribution of wealth the apparent interests of the two parties are antagonistic, and, given the amount produced, the larger the share of the one, the less will be that of the other. The frank recognition of this possible antagonism is the first step towards the prevention of its natural consequences. The imminence of the possibility supplies the strongest motive for removing unnecessary hindrance, and furnishing likely assistance, to a pacific agreement. And, whatever the final consequences of a dispute to the interests of either party, the existence of friction and irritation is beyond question an injury and hindrance to production. The loss thus occasioned is immediate as well as distant, and may be considerable; but, if the telescope of the economist is generally needed to bring sufficiently close the ultimate effects of industrial disputes, his microscope is sometimes required to magnify the results of friction to dimensions which will attract and retain the attention of the ordinary observer. By discovering these deeper considerations beneath the superficial appearance of affairs economics may furnish useful guidance in the prevention and adjustment of industrial disputes.

For to what conclusion do these considerations lead? To the discovery of some machinery which may prove not unacceptable, and yet, by imposing delay on the outbreak of strife, may allow the two parties to hear what either has to urge, and to consider the possible consequences of the action they are proposing to take. Such a machinery may be discovered in boards of conciliation and courts of arbitration. The fact that both sides should be organised on a sufficiently responsible basis to send accredited representatives; the fact that, thus meeting one another, they are compelled to seek and adduce reasons for their own position and to listen to the arguments in support of their opponents; the fact that delay and deliberation are recognised preliminaries to the commencement of war—these facts may not appear important in themselves, but they offer a chance of pacific adjustment, and afford opportunity for the consideration of ulterior issues. They prevent the apparent interests of the moment from winning an undisputed victory over the less obvious interests of the future; and they do not allow an advantage in distribution to be secured without thought of the effects on production. On the other hand, the antagonism of interests incident to the distribution of wealth, when the production is regarded as a given quantity, suggests that the machinery may on occasions break down, and that the arrangements should properly consist of different stages and provide supplementary resources; for arbitration may succeed in adjusting a dispute to which conciliation has proved incompetent, and conciliation may conceivably be useful where arbitration has been ineffectually tried. Such antagonism also suggests that voluntary adhesion is likely to be more abiding than compulsion, and more conducive to the permanent interests of peace, and that to prevent the occurrence, or reduce the likelihood, of industrial conflict a traditional standard of settlement, changed in grave emergencies or serious vicissitudes alone, should be established in the trade and recognised as fair.

For economics, as it seems to me, can do little more than point out those ultimate and obscure consequences which are concealed by immediate superficial appearances; and it is not in possession of a precise principle or rule, which can be definitely applied to the determination of industrial disputes. Could it, indeed, furnish such a rule, the argument in favour of the legal bestowal of compulsory powers on courts of arbitration and boards of conciliation would gain considerable strength; for it must be remembered that the questions before them are not the interpretation of past contracts, such as are habitually submitted to the Continental Conseils de Prud'hommes, but the establishment of agreements for the future, and it is difficult to force parties to agree when you do not supply a principle of agreement, nor does it on the whole seem likely to conduce to conciliatory relations to declare that, while you will not compel masters and men to agree, you will compel them to abide at all hazards by the agreement to which they may come. For these reasons, tempting as it undoubtedly is to invoke legal compulsion, I believe that the State can do little more than supply facilities for voluntary agreement and, exercising, perhaps, some gentle persuasion, leave the pressure of public opinion to induce recourse to machinery thus provided. Such I take to be the drift of competent experienced opinion and the probable scope of effective legislation; and such, as it seems to me, is the kind of guidance which economics can offer on this practical question.

II. In a town like Ipswich we are forcibly reminded of another question of the day—I mean agricultural depression. From the Reports of the Assistant-Commissioners to the Royal Commission it would appear that the county of Suffolk shares with its neighbour, Essex, an unenvied pre-eminence among districts which have suffered, and that the present condition of this important industry borders here on despair. In the actual words of Mr. Wilson Fox, the Assistant-Commissioner, agriculture in Suffolk 'is well-nigh strangled.'[1] Can economics throw any light on this lamentable situation? If there is one theory which is supposed to be more remote from fact than another, it is the theory of rent. It is the fashion, even with professed economists, to regard it as unduly abstract; and, in a recent address[2] to a learned society connected with this Section by no distant ties, the President selected the theory as a conspicuous example of older formulæ laid aside. The account of the theory given in that address is open to question, but the ground of rejection is worthy of note. Lord Farrer, it would seem, condemns the theory because it is a 'formula useless for practical purposes.' This criticism raises the question we are now considering; for we are trying to ascertain the guidance which economic science can furnish in practical affairs. That it has an important, and, indeed, a necessary, relation to practice we have asserted in positive terms; but the relation is not, as we think, that which Lord Farrer apparently assumes. For economics does not furnish precepts or formulæ immediately applicable to practice; but it supplies systematised knowledge, the possession and employment of which will afford assistance in the direction of practical affairs. The theory of rent is not, then, a maxim of conduct but a rational explanation of fact. Conceived thus, in my own experience as College Treasurer, I have been struck by its pertinence, not its inadequacy. It has certainly seemed to me that, on a broad view, the tenant considers the rent to be properly that which is left when, on an average of years, he has reaped a fair profit and paid his labourers the wages they command. The landlord, so far as I have been able to discover, occupies in his eyes the position—to use language differently applied[3] by General Walker—of a 'residual claimant'; and such, also, as I read the theory, is the place which he fills therein.

Nor is it difficult to interpret part of the present depression in conformity with the theory of rent. I must take leave to dissent from Lord Farrer when he asserts that the formula, even in its older shape, paid no regard to situation or to means of transport; and I am disposed to affirm that the emended statement of recent text-books, in which these considerations, with others mentioned by Lord Farrer, receive explicit recognition, is not so much a departure from the older form as a development and extension of it. But, taking the two points of fertility and situation alone, it is the agreement, and not the conflict, of what has happened with what the theory might have led us to expect that is likely to impress. It can hardly be doubted that one of the most remarkable changes of recent years has been the development of the means and reduction of the cost of transportation. This change implies a loss of the advantage derived from proximity to the market in the case of commodities which admit of conveyance from a distance. Interpreted in the language of the theory of rent, English land, as respects certain products, has forfeited part of the natural protection afforded by its situation near to the market. With the partial loss of this advantage has also disappeared part of another, for the diminution in the cost of transportation has opened European markets to the virgin soils of America and other countries; and, with regard to products which admit of conveyance from a distance, the fertility of English land, whether it be due to the skill of generations of comparatively high farming or to natural qualities of soil, has lost part of its advantage. In the language of the theory of rent, the forfeiture of these two advantages involves depression in the sense of a decrease of rental; and, as it seems to me, the adequacy rather than deficiency of the theory is evident as a rational explanation of fact.

Nor is it useless for practical guidance. The fact which it establishes is a

[1] Cf. *Report*, p. 82.

[2] Cf. *Journal of the Royal Statistical Society*, vol. lvii. Part IV., December 1894, pp 595, &c.

[3] *I.e.*, to the wage-earner. Cf. *Political Economy*, by F. A. Walker, Part IV.

connection between cause and effect, and not a maxim of conduct; for the laws of economics, like the laws of every science, are, as it has been aptly expressed, statements in the indicative and not the imperative mood. But the possession of the scientific knowledge of the causal connection is more likely than its absence to conduce to prudent practice. In the instance before us the conclusion seems inevitable that, so far as the depression is due to foreign competition, and the virginity of competing soils, and facility of transportation, continued attention to products, which must be conveyed to their market quickly, is likely to be more profitable in an old country like England than the continued production of commodities, which can be raised to greater advantage on newer soils, and be easily transported from considerable distances. I am aware that this is a hard saying, that necessary conditions of cultivation, sometimes neglected, must be taken into account, and that such a change as is often contemplated in such discussions may mean a painful and difficult departure from traditional habit, and an apparent sacrifice of inherited or acquired skill. It is easy to talk glibly of the English farmer abandoning the cultivation of cereals, at any rate as a staple product, and turning his attention to vegetable and dairy produce, to fruit-raising and poultry-rearing and bee-keeping, and the various other modes of making a fortune which are put forward for his edification. But the lesson of economic theory is plain so far as the depression is due to foreign competition and the maintenance of a Free Trade policy is assumed.

I do not discuss the latter question, because it is far too large to be adequately treated in a paragraph or two, and is excluded from practical politics by the leaders of political parties; but it is certainly a question on which economics may reveal the unseen. Among those invisible facts may perhaps be placed a circumstance often neglected in popular discussion. In many arguments on agricultural depression the landed interest is treated as strictly separable from the rest of the community, and a fall in rent is regarded as the loss to a particular class of an advantage enjoyed apart from exertion.

If I may say so in passing, some of the abundant popular use made in recent years of the conception of rent as an unearned increment seems to me to afford an example of the misapplication of theory to practice. For in not a few instances what has happened is this: A theory resting on nice distinctions has been crudely applied to practice, and the distinctions employed to prescribe a definite policy without regard to their nicety. In other words, the theory has been used as a precise maxim, which could be straightway embodied in practice, and not as a scientific conception, the knowledge of which might protect the practical man from hidden pitfalls.

In England, at least so far as agricultural land is concerned, the landlord is usually a partner with the tenant, and, whether or not the system be better than that of occupying-ownership, it is certain that part of the rent is a return for expenditure, and not a payment for natural qualities of soil or situation; and to this extent a fall in rent is likely to operate as a discouragement or preventive of the fresh and continuous expenditure needed to maintain the land and the buildings in a state of efficiency. I cannot doubt, in view of evidence given before the Commission on Agriculture, and of other signs, that the depression must have already produced deterioration in this respect, and thus have injuriously affected the economic position of the general community.

Nor is the landed interest strictly and entirely distinct. In an old country different classes are connected with one another by ties hard to disentangle, and impossible to sever without injury or danger. The educational endowments of the country, as a melancholy personal experience has taught me,[1] cannot regard agricultural depression with the complacency of disinterested observers. The effect on certain public institutions, like some of the London hospitals, is notorious; and it can scarcely be doubted that, though the prudent management by which they are characterised may have led many of the great insurance companies to write down

[1] *Cf.* papers read by the present author to the Royal Statistical Society in February, 1892, and January, 1895.

their landed investments and withdraw from them as they are able, yet they have been, and are, largely interested in the fortunes of landed property, and perhaps especially in the rentals of landlords, on the security of which they have made advances. With the stability of the insurance companies is linked the preservation of perhaps the bulk of the savings of the professional classes. In short, in an old country a strict separation between the interests of different classes is only true with large deductions.

III. But economics also raises and solves the doubt whether depression in agriculture can be attributed to foreign competition alone. It is a significant fact that, according to authoritative accounts, many of the competitors of the English farmer have not escaped the distress from which he has suffered; and in England the depression, in spite of constant reductions and abatements, has exerted an influence on profits scarcely less grievous than that on rents. These circumstances certainly lend weight to the contention that the fall of prices, which is not peculiar, though perhaps especially discouraging, to agriculture, is partly due, to state the matter in the least controversial shape, to a change in the general relation between the supplies of gold and the monetary work that it is required to perform. To the discovery of a cause like this, hidden from superficial view, and to the indication of the manner in which it may affect the position of agriculture and other industries, economics, by virtue of its mission to discern the unseen, is peculiarly competent. I do not propose to enter now at any length on the vexed question of the currency, but it is certainly a prominent practical question of the day. It is a question on which the economist may claim to speak with authority, and the practical man may demand, as he may be expected to follow, the definitive guidance of expert opinion. On this question, perhaps, in particular, the unassisted vision of the naked eye may form erroneous conclusions, and derive no little profit from the use of the optical instruments provided by the economist.

I cannot preface what I propose to say more appropriately than by a quotation from Jevons. In that pamphlet on 'A Serious Fall in the Value of Gold'[1] which has attained the rare dignity of an economic classic, commenting on the alarmist anticipations of Chevalier and Cobden, he remarks that the alteration in the value of gold consequent on the discoveries in California and Australia would probably be 'most gradual and gentle.' 'Far from taking place with sudden and painful starts, flinging the rich headlong to a lower station, and shaking the groundwork of society, nothing is more insidious, slow, and imperceptible. It is insidious because we are accustomed to use the standard as invariable, and to measure the changes of other things by it; and a rise in the price of any article, when observed, is naturally attributed to a hundred other causes than the true one. It is slow because the total accumulations of gold in use are but little increased by the additions of any one or of several years. It is imperceptible because the slow rise of prices due to gold depreciation is disturbed by much more sudden and considerable, but temporary, fluctuations which are due to commercial causes, and are by no means a novelty.' I propose to apply briefly these remarks of Jevons to some aspects of the controversy which has arisen on the cause of the fall of prices of the last twenty years.

It is, for example, sometimes asserted that the influence of credit on prices is so considerable as to reduce to unimportance a decrease in the available supplies of gold. It may at once be admitted that the modern extensive development of credit obscures the relation between the metal and prices; but it does not destroy it, and, according to the view we have been trying to emphasise, the mission of economics is to remove this veil of obscurity. In this instance it may show that the relation is not unreal because it is indirect; that credit, expanding and contracting of itself owing to increasing or diminishing speculative activity, is yet limited and controlled in its movements by the changing dimensions in the basis of cash on which it rests; and that, through the bank reserves meeting or restricting the demands for petty cash and permitting an expansion or causing a curtailment of credit, the supplies of the standard metal exert an important influence on prices.[2]

[1] Cf. *Investigations in Currency and Finance*, pp. 78, 79.

[2] *Cf.* Giffen's *Essays in Finance*. Second Series, II.

Economics may thus furnish a rational account of the *modus operandi*, and statistics supply corroborative evidence. This evidence, indeed, may be said to amount to ocular demonstration, for no one who has studied with moderate attention the course of a curve of general prices over a period of time, drawn in accordance with the graphic method of statistics, can have failed to distinguish the different character of the fluctuations thereby shown—to have separated the more obvious and pronounced fluctuations of credit, marking the flow and ebb of confidence, from the minor passing changes due to some temporary accident of demand and supply on the one hand, and, on the other, from the general trend of the curve indicating a growing abundance or scarcity in the available supplies of the standard metal. This is a broad influence, the operation of which is only discernible on a comprehensive view; but the graphic method of statistics brings it within the range of ordinary vision, and the reasoning of economics discloses the connection of the phenomena. The influence of credit is apparent on the surface, but the deeper influence can be detected beneath; and, if the general level of one credit cycle be higher or lower than another, the change points to the presence and action of some less obvious cause. In a modern commercial society, with its development of banking and credit, we are able to observe and to measure cause and effect. At the one end of the process we possess statistics of the production of gold, and can frame estimates of the amount and character of extraordinary demands.[1] At the other end we can employ, in the form of index-numbers, as they are called,[2] a means of measuring changes in general prices, which is certainly adequate to show the direction of the change, if it is not competent to indicate its precise amount. For the connection between cause and effect we look to economic reasoning, which here, as elsewhere, enables us to discern the unseen.

A similar test may be applied to the adequacy of some other causes. It is sometimes said that a complete explanation of changes in general prices can be discovered in the particular circumstances of individual commodities, without any reference to a common cause. The answer is evident on the principles we have been endeavouring to establish. Those particular circumstances lie on the surface, and the common cause is only apparent if we penetrate beneath. Here, again, economics is aided by statistics. Economics can recognise and explain the operation of a common cause in enhancing or diminishing the effect of particular circumstances, and statistics can offer corroborative evidence of the presence of such a cause. For the very meaning and intention of a statistical average is to eliminate the influence of particular causes, and therefore the testimony of those index-numbers, in which an attempt is made to exhibit the average change in prices, is adequate to establish the influence of some common cause, if the basis on which they are constructed be sufficiently comprehensive and typical. It can scarcely be doubted that this criterion is satisfied in the case of some of the best-known varieties. The presence of that common cause, it must be remembered, does not imply the absence of other contributory or counteracting causes; and the inquirer in the region of the moral and political sciences is always beset by difficulties arising from the plurality of causes. But, if he can establish the presence of a common cause competent to produce the effect, and can point to the effect which has been produced, the argument for the connection between the two attains that high degree of probability which is all that we can expect to reach. In the instance before us statistics may show the presence of this common cause and the occurrence of the effect, and economics may indicate the competence of the cause to produce the effect. We know that until recently the production of gold had declined from the level reached in the middle of the century, and we are aware that a series of extraordinary demands[3] had coincided, while various index-numbers are in general agreement in

[1] To some extent also this is true of the changes in the ordinary demands, but the stress of the argument may be laid on the extraordinary demands.

[2] *Cf.* those compiled by the *Economist*, Mr. Palgrave, Mr. Sauerbeck, Dr. Soetbeer, and Sir Robert Giffen.

[3] *E.g.*, on the part of Germany, the United States, the Austro-Hungarian Empire, and Russia.

exhibiting a fall in prices, though the degree of the fall shown in each case may vary.[1] The economic theory of supply and demand may, then, be used to establish the connection between cause and effect; for, if the supply of a commodity declines while the demand for it increases, a rise in its value, and a fall in the value of articles compared with it, become inevitable. Such has been the position of gold during the last twenty years.

It may be noticed that the possibility of a plurality of causes increases the likelihood of the action of some common cause; for, under the conditions, we cannot expect the apparent effects of this cause to be immediate or universal. The presence of counteracting or modifying circumstance, of opposing or contributory causes, will delay in some cases a process accelerated in others, will minimise here an effect which is accentuated there. The apparent change due to the cause is only likely to be general and not universal, to be gradual and not immediate. The assertion that a fall in prices, if due to an alteration in the available supplies of the standard metal, should be immediate and universal cannot be sustained when economics, penetrating beneath superficial appearance, reveals the interaction of different causes; and, if the testimony of index-numbers points to a general change, it is no sufficient answer to affirm that it is not universal. On grounds of economic reasoning we should expect a slower movement of retail than of wholesale prices, of the prices of articles of minor than of those of more general consumption, of wages than of prices generally.

The mention of wages suggests another point neglected in some current discussions, but brought by economic reasoning from obscurity into prominence. It is sometimes asserted that the fact that wages have not fallen is a proof that monetary causes have not produced the fall of prices. But, apart from the known tendency of wages to move more slowly than prices, such an assertion overlooks the possibility of a simultaneous change in distribution. Economic reasoning points to the probability of such a change in favour of the wage-earner, and to the effect that it would produce; and statistical evidence corroborates that reasoning.[2] If such a change be proceeding, we should expect wages to rise, and the fact that they are stationary tends to prove, not to disprove, the existence of a monetary cause of the fall of prices. A failure to give explicit recognition to this possibility is due to neglect of the plurality of causes, and is akin to another argument sometimes advanced. This maintains that, if it can be shown that the country has progressed, or not receded, in wealth, in the development of trade and manufacture, in the prosperity of the mass of the community, it is thereby proved that the fall of prices has wrought no injury. But it may be answered that the progress might have been greater in the absence of the fall, and other forces may have prevented the cause in question from producing its full effect. Here, again, economic reasoning may aid in discerning what is invisible to the unassisted eye.

Few truths, indeed, are slower to receive, and more likely to lose, popular recognition than those which lay stress on the mutual action of different causes. We are told, for instance, that the fall of prices is due to circumstances connected with improvements in the production and transportation of commodities; and it must be admitted that such a common cause is not, like particular causes affecting individual commodities, eliminated in the general average of the index-numbers. But the one common cause—that of improvements in production—does not exclude the operation of the other—that of a change in the available supplies of gold. Taking a broad view of the whole century, it would certainly seem that the movement of improvement has set steadily in one direction, but that the movement of prices has first declined, and then advanced, and then declined again. It is possible that the movement of improvement may have been accelerated and retarded at different times; but the change in the movement of prices, which requires ex-

[1] An index-number may be briefly described as a mode of showing the average change in prices by comprising in one grand total the percentages of rise or fall shown in the recorded prices of certain selected typical commodities.

[2] *Cf.* the investigations of Sir Robert Giffen in England, of M. Leroy-Beaulieu in France, and of other inquirers in other countries.

planation, is not a variation of degree, but a reversal of direction. And this reversal coincides with similar changes in the available supplies of the standard metal. If the disturbances in America at the beginning of the century, with the known diminution in production, were followed by a fall, if the Californian and Australian discoveries of the middle of the century were accompanied by a rise, and if the notorious extraordinary demands since 1873, statistically computed by Sir Robert Giffen,[1] coming on a supply which until the past few years was diminishing, coincided with a fall again, it seems impossible to doubt that, although improvements in production and transportation may have been contributory causes, an important influence has been exerted by the monetary supplies. With the aid of the economic telescope and microscope forces too remote or obscure to be detected by the naked eye are thus brought within the range of ordinary vision; and the action of the standard metal on prices is one of those forces, for, in Jevons's language, it is 'insidious, slow and imperceptible.'

Such is the guidance which, as it seems to me, economics is able to offer; and in this question of the currency, as in the others of which we have treated, it is surely not destitute of practical import, for the detection of a monetary cause of the fall in prices is so far an argument for the adoption of a monetary remedy. Such guidance also, I believe, economics can furnish on many other questions coming to the front; and, in offering this, it cannot be accused of an excessive or defective estimate of its claims to popular recognition. I am convinced that, as the years elapse, its aid will be sought with increasing urgency, and that it will discharge, with a fuller consciousness of its high prerogative, its important but difficult mission of seeing for itself, and disclosing to others, the unseen.

The following Papers were read :—

1. *Comparison of the Rate of Increase of Wages in the United States and in Great Britain*, 1860–1891. *By* A. L. Bowley, *M.A.*

The basis of the calculation is the Senate Report on Wholesale Prices, Wages, and Transportation, 1893, with which is compared the author's estimate of the change of average wages in the United Kingdom, published in the Journal of the Royal Statistical Society, June 1895.

On examination it is found that the final wage tables of the Senate Report do not rest on sufficient data, that no account is taken of the relative importance of different occupations or of the different levels of wages, and that the figures for many of the industries included are based on very slender information. The industries for which the data appear on analysis to be sufficient are selected, and the average wages in these industries reworked for certain years directly from the original table of wages. By this means the relative wages for these selected trades are found, on a method more correct than in the Report, for the years 1860, 1871–3, 1879–80, 1883, 1886, and 1891.

These relative wages are compared individually and collectively with the corresponding figures already found for the United Kingdom; and it is seen that money wages have followed very much the same course in both countries, rising to a maximum in 1873, falling till 1880, and then rising till in 1891 the level of 1873 is again reached. Wages in the wool-trade follow a different course, and do not make much progress in England, whereas in the States they increase rapidly after 1873.

To estimate the relative change in real wages, it is necessary to find index-numbers formed on the same plan for both countries. This is done in three ways: Sauerbeck's numbers are first compared with similar numbers for the States; secondly, they are grouped and weighted, and compared with weighted numbers given in the Senate Report; while a third series is found from certain wholesale prices compiled and grouped in the same Report. After discussion, the second of

[1] In evidence given before the Gold and Silver Commission, and, more recently, before the Commission on Agriculture.

these series is chosen; the relative money wages are corrected by these index-numbers, and results are deduced from the relative real wages so computed. It is now found that, in the limited area of industry considered, real wages have increased continuously in the United Kingdom, till they stand more than seventy per cent. higher in 1891 than they did in 1860; while in the States real wages rose with the same rapidity till 1873, were checked, and finally fell in 1880, and then rose rapidly till in 1891 they were nearly sixty per cent. higher than in 1860.

These conclusions must not be taken to represent industry in the States or in England as a whole, since it has not been possible to include agricultural wages.

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2. *Bimetallism with a Climbing Ratio.* *By* HENRY HIGGS, *LL.B.*

FRIDAY, SEPTEMBER 13.

The following Papers were read :—

1. *The Normal Course of Prices.* *By* WILLIAM SMART, *M.A., LL.D.*

What course may prices be expected to take in a period of normal industrial activity? Practical men, seeing that, in one or two well-known trades, reduced material and freights, improved machinery, centralisation, and gigantic production sum up a lower cost of production, generalise this, and assume that a steadily falling *level* of price is inevitable as the expression of reduced cost.

But, on looking through money price to exchange values, it becomes obvious that reduced cost takes effect in increase of supply, and that prices come down only in default of corresponding increase of demand. What is usually forgotten is that every change in supply means a change in demand, the two being different aspects and names for the same goods.

(1) Every increase of supply (reduction of price) of any article calls out a new demand for it, and prevents the fall in price being proportional to the fall in cost. The present congestion of capital and labour conceals this; because manufacturers can just now get both at low rates, we unconsciously assume that there could be indefinite production of any article without increase of cost. (2) Every increase in the total product of industry is a new demand for goods generally, just as truly as would be a chance discovery of sovereigns in an old drawer.

Suppose A products and B products represented the national output. So long as A and B increased simultaneously and harmoniously, there would be indefinite increase of both supplies without fall of exchange values. If now the same capital and labour doubled A product, while B product remained constant, the exchange value of every A would, in terms of B, fall to one half. If subsequently B products experienced the same increase, every A would again rise in terms of B. Recognising that no two articles have equal elasticity of demand, and that this subsequent rise of price and its extent cannot be foreseen, the essential fact remains that every particular increase of supply is increase of general demand. This being so, reduction of cost, which is the real characteristic of prosperity, will find expression now in falling price, now in rising price; the falling price being due to increased supply of the particular article, the rising price being expression of the increased supply of other articles.

Conclusion: that, so far as the late fall in prices is general, it cannot be due to causes inside the production process; and this seems to point to a contraction of the universal commodity in which all goods (and all costs) are named.

Corollary: that if manufacture—that is, the employment of the masses—is to remain subject to steadily falling prices, the manufacturer will require to find some new means of paying himself for his work. Otherwise he will find it in speculation or in combination to sustain price artificially.

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2. *A Proposal for a System of International Money.* *By* W. A. Shaw.

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3. *The Gold Standard.* *By* Hon. George Peel.

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4 *The Menace to English Industry from the Competition of Silver-using Countries.* *By* R. S. Gundry.

Although England has had a single gold standard since 1816, all other countries continued to use either silver alone or both metals linked together, as full legal tender money, till 1873. Down to that year, therefore, gold and silver served equally as international money. The demonetisation of silver, which began with Germany's adoption of a gold standard, has entailed a gradually increasing divergence in the relative value of the two metals. The value of gold necessarily rose in response to increased demand, and the price of all commodities (as measured in gold) fell. The price of silver fell with the rest, and is now 30*d.* an ounce, instead of 60*d.*, at which it stood so long as the French mints were open to coin it at the ratio of 15½ to 1.

But though silver may appear in Europe to have shared the general fall, the position is different if we turn to the East. The standard there *is* silver, and its purchasing power over commodities has remained approximately stable. To an Indian, or a Chinaman, or a Japanese, his silver money represents the same value that it did twenty years ago. The English farmer who wants a sovereign has to give two sacks of wheat where one used to suffice; but the Indian ryot who wants a rupee has to give no more of his produce than before, and his rupee will buy in turn as many of the necessaries of life as it would a generation ago.

The effect has been to encourage the importation of foreign produce into England, and to render increasingly difficult the exportation of English industrial products to the East.

It is an error to suppose that the great fall in wheat, for instance, has been caused by competition in the United States. The American farmer, on the contrary, is suffering nearly as we do ourselves. The root of the evil lies in differences of currency. As a sovereign, which used to be worth only ten rupees, will now buy eighteen, and each rupee retains its purchasing power, it follows that a sovereign will buy nearly twice as much Indian wheat, and the price of English corn had to fall accordingly. The close of the Indian mints disadvantaged India in turn by lifting her currency above the silver level, and she is being undersold by Russia.

The Lancashire manufacturer who wishes to sell his goods in Asia is confronted by the converse difficulty. As the Chinaman's dollar represents, to him, unchanged value, he is not disposed to give more silver for his yarn or cloth than before. But whereas the dollar used to be worth 4*s.*, it is now worth only 2*s.* 1*d.*; so that the English manufacturer who used to get, say, (2½ =) 10*s.*, now gets 5*s.* 3*d.* The effect has naturally been to check trade. The proportion of total exports of British and Irish produce taken by silver-using countries since 1876—when the currency changes had had time to take effect—has been stationary. It was 20·67 per cent. in 1877 and 20·85 per cent. in 1894, having never been above 21·90 in the interval. The export of cotton yarn from England to China and Japan is less now than it was in 1876, while the export from India has enormously increased; though there has been a falling off in her case also since the close of her mints (in 1893) disturbed—by imparting a fictitious value to the rupee—the silver level on which the trade had grown up. The additional blows dealt to silver and the increasing strain thrown on gold by that measure and the repeal of the Sherman Act disabled the English manufacturer still further. The gold price of silver fell another 10*d.* He was obliged to raise the price of his goods in order to ensure an adequate gold return, and the Chinaman restricted his demand. The import of cotton goods into China in 1894 was less by 4,000,000 pieces than in 1892.

Nor does the harm end here. The conditions which handicap English labour advantage the Asiatic and encourage him to manufacture for himself.

As the local value of the Japanese *yen*, for instance, has not changed, whereas it has come to represent 2*s*. only, instead of 4*s*., to the English manufacturer, the latter is obviously at an enormous disadvantage in the competition. The result is that not only is Japan now manufacturing many things which it used to buy from us but, having satisfied its own requirements, is beginning to export. It is beginning to export cotton goods to China and the Straits at prices with which we cannot compete. It already supplies Singapore with half the coal used at its wharves, to the detriment of Wales and Australia. It supplies, not only to China, but to the Straits, and even to India, numerous minor articles which we used to send when the dollar represented 4*s*., but which we cannot supply for 2*s*. And what has been going on in Japan is beginning in China, where cotton mills are being erected in turn. This competition is only in its infancy; and we have here the obverse of the picture of cheap prices upon which advocates of the gold standard love to dwell. They may be pleasant for the consumer, but how about the producer? They may be good for the creditor, but how about the debtor who has to produce two hundred sacks of wheat to repay the 100*l*. which he borrowed when it represented one hundred sacks? The advantage, to the hypothetical labourer, of being able to buy a loaf for $2\frac{1}{2}d.$ instead of 4*d*. is obvious, if he retains his former wage; but how about the man whose wages have been reduced, or whose occupation has been lost through the change of arable land to pasture or by the close of a Lancashire mill or a Cornish mine? If low prices be a supreme good, to be pursued at the cost of transferring English industries to the East, we have only to persevere in the boycott of silver which is ruining agriculture and saddling Lancashire with a handicap too heavy to be borne. But it is well to realise that all this means loss of work; and to the workman who has less wages or no work cheap prices may seem a questionable boon. The close of the mints against silver has practically divided the world into two halves—one of which is prospering on a stable and abundant silver currency, while the West is suffering from financial stress and from hindrance to its commerce with the East. An agreement to join other nations in resuming the free coinage of both metals at a fixed ratio would relieve us from these disabilities by re-establishing parity of exchange, and replace our farmers and manufacturers on even terms with the rest of the world.

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5. *On the Preservation of the National Parochial Registers.* *By* H. PATON, *M.A.*

The early parochial registers of births, marriages and deaths in England and Wales and in Ireland are still located in the several parishes to which they relate. This exposes them to the many risks contingent to the numerous and varied forms and places in which they are kept; often to the mercy of careless or incompetent custodians; and, on account of their being so widely scattered, renders them practically inaccessible for either statistical or general or special historical purposes. The valuable information they contain is accordingly almost entirely lost to the country. This could easily be remedied by the adoption of the method which has been followed in Scotland. There, by an Act of Parliament, in 1854, the custodians of such parish registers were required to send them to the General Register House at Edinburgh, where, under the care of the Registrar-General, they have been carefully gone over, strongly bound, and are now preserved in uniform order in fire-proof and damp-proof chambers. They are open daily for inspection to those interested on the payment of certain fees, and when for purely literary work, *gratis*. The passing of a similar Act of Parliament for England and Wales and for Ireland, by which the present custodians of parish registers in these countries shall be required to send all such registers (in the case of England and Wales) to the Record Office or to Somerset House in London, and (in the case of Ireland) to Dublin Castle, or other safe repository in Dublin, would secure the same benefits to the rest of the British Isles as Scotland now enjoys. Besides, the registers themselves would enjoy the greatest possible security from the further inroads of fire, of damp, and of other destructive agents, which have already made havoc with so many of our early national records; and a most valuable source of historical and statistical information would be available for the student at readily accessible centres. When desired by any parish, as has been done in Scotland, a certified copy of the registers of such parish could be made at the public expense, and this copy left in lieu of the original.

SATURDAY, SEPTEMBER 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

The following Papers were read :—

1. *Agriculture in Suffolk. By* CAPTAIN E. G. PRETYMAN, *M.P.*

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2. *Agriculture of Suffolk from a Tenant's Point of View. By* HERMAN BIDDELL, *Playford, Ipswich.*

Soils of the County.—Short description.
Cultivation as hitherto adopted.—Corn growing; sheep rearing.
Dairying.—Milk trade; butter making; butter factories; cheese making.
Grazing as a substitute for corn growing.—Bacon factories.
Proposed substitutes for corn growing.—Sugar beet; flax; vegetables; market gardening; fruit culture.
Suggestions for relief of present distress by adjustment of railway rates and of local taxation.
Imperial attention to sale of foreign for home-grown meat.
Increased price of produce, &c.

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3. *Co-operative Rural Banks. By* HAROLD E. MOORE, *F.S.I.*

At the present time much attention is rightly given to the extension of allotments and small holdings, either as a useful auxiliary, or as a sole means of livelihood. It is too often forgotten, however, that both skill and the assistance of adequate capital are necessary if such areas of land are to be made as useful as possible. Thus, a man may want additional funds before he can purchase a cow, or other live stock, or plant fruit trees. Even if an individual possesses half the amount necessary for these purposes, without co-operation he has no means of obtaining the other half. This difficulty can now be overcome by adopting the principle of co-operation in any parish in which this additional capital for productive purposes is wanted. This co-operation should be applied by the foundation of a society or co-operative bank which would lend to the individual members, under proper conditions, the sums they require. These conditions would provide that no loan should be lent except to members of the society, and that in each case it must be for some specified productive purpose approved by the committee, and for which securities or sureties approved by them are obtainable. The funds required by the co-operative bank would be provided from an ordinary bank, the latter holding the charges given by the individual borrowers, and having an additional security in the unlimited liability of the members of the society. Such banks had been most successful on the Continent, as would be shown in the succeeding paper by Mr. Wolff, but in consequence of legislative difficulties, had only lately been introduced into England. These, however, had been removed by the action of the Agricultural Banks Association, founded in 1893. Any interested in starting a co-operative bank in the district with which they are concerned should apply to the Secretary of that Association, Palace Chambers, Westminster, S.W., for a copy of the rules as approved by the Registrar appointed under the Friendly Societies Act, 1875.

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4. *Co-operation in the Service of Agriculture. By* H. W. Wolff.

Co-operation seems marked out as one of the methods by which help may be brought to agriculture. The method proposed is not what is usually understood as 'Co-operative Agriculture,' that is, the joint tenure and exploitation of a holding by a number of men, which does not generally seem to answer, and which promises no relief to farmers in the ordinary sense of the term; but co-operation in the purchase of farmers' requisites; in turning farm produce to better account—for instance, milk by means of co-operative dairies; in practising combined selling, insurance, the disposal of meat in co-operative butcheries, in common work of certain kinds, and in the securing of credit by means of co-operative banks. Instances quoted from home and foreign experience. It was really we who began co-operative agricultural supply. It did not spread as it should have done, apparently from want of money. Now the foreigners have outstripped us. The French agricultural syndicates, started in 1883, have now increased to about 1,500. They have 'democratised' the use of feeding stuffs and artificial manures. They have achieved success on other ground. The Italian syndicates and co-operation in Germany and Switzerland were then described. The most effective co-operative method thus far applied has been co-operative credit, which is now placing millions at the command of cultivators, large and small, in Germany, Austria, and in Italy, which is spreading and generally answering very well. The problem to be solved stated. Credit must be granted for long terms and on security, which is not now recognised. It must also be made available alike for large farmers and for small cultivators. The credit must be personal. Examples quoted from abroad. Different systems. That of Schulze Delitzsch, of Luzzatti, of Raiffeisen, and their further adaptations. Applicability of the same principle to England. Village banks for small cultivators, allotment holders, &c. Agricultural banks of a different type for larger farmers. Our difficulties and our advantages. On the whole there seems room for this form of co-operation, as there certainly is for the other forms touched upon. There is a want of money among farmers. The new allotment holders certainly will want such help if they are to prosper. The legal difficulties have practically been overcome. Our beginnings seem to warrant expectations of further success.

TUESDAY, SEPTEMBER 17.

The following Papers were read:—

The Probability of a Cessation of the Growth of Population in England and Wales before 1951. *By* Edwin Cannan.

Everyone knows that the population of a country increases when births and immigrants exceed deaths and emigrants, and decreases when deaths and emigrants exceed births and immigrants, and most people know that though emigration and immigration fluctuate greatly, the effects of migration on the population of England, as a whole, are small compared with the effects of births and deaths. But the ordinary citizen does not usually realise the extent to which the deaths of each decade are dependent on the variations of the number of births in the preceding half-century. Yet this dependence is so well understood that in the Census Report of 1861 it was predicted that the population over twenty years of age in 1881 would be 14,167,745, and the Census of 1881 enumerated 13,958,616, so that the error was only 15 per thousand. Again, in the Census Report of 1871 it was predicted that the population over ten years of age in 1881 would be 19,365,188, and when the time came 19,306,179 were enumerated. If the same method had been used in 1881, the population over ten in 1891 would have been estimated at 22,129,736, and the number enumerated was 22,053,857. In both these last cases the error is between 3 and 3½ per thousand.

The diagram exhibited shows the basis of these estimates and continues the series to 1951. The population at each age living at every moment between 1851 and 1891 is indicated by lines sloping downwards, and the gradual progress of each generation from the birth of its first member on the Census morning to its final extinction by the death of its last survivor more than a hundred years afterwards, is shown by lines sloping upwards from left to right. From the form of the figure it will be seen at once that while an immediate cessation of the growth of population is, in the absence of some great convulsion, altogether out of the question, a gradual diminution and eventual cessation before the middle of next century is quite compatible with all reasonable continuity.

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2. *On the Correlation of the Rate of General Pauperism with the Proportion of Out-Relief given. By* G. U. YULE.

The author had formed two correlation tables for the years 1871–1891, showing the number of unions in each year, combining given rates of pauperism with given proportions of out-relief. The result showed that the rate of pauperism was indubitably correlated with the proportion of out-relief given, high values in the former corresponding to high values in the latter (on the average). As this was in flat contradiction to a conclusion of Mr. Charles Booth's,[1] an investigation and critique of his methods were also given.

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3. *The State and Workers on the Land. By* Rev. J. FROME WILKINSON.

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4. *The National Value of Organised Labour and Co-operation among Women. By* MRS. BEDFORD FENWICK.

[1] *Aged Poor*, p. 423.

SECTION G.—MECHANICAL SCIENCE.

PRESIDENT OF THE SECTION—Professor L. F. VERNON HARCOURT, M.A., M.Inst.C.E.

THURSDAY, SEPTEMBER 12.

The President delivered the following Address:—

The Relation of Engineering to Science.

THE selection of a subject for an inaugural address, necessitated by the honour conferred upon me of presiding over this Section, has been rendered peculiarly difficult, both on account of the numerous able addresses delivered in past years by my eminent predecessors in this office, and also by the circumstance that the branches of engineering to which most of my professional life has been devoted have not as intimate a connection with mechanical science as some others. Moreover, whilst former Presidents of Section G have frequently dealt, in their addresses, with the progress of those special branches of engineering in which they have had most practical experience, such a course, in the present instance, would have exposed me to the danger of merely repeating information and reiterating opinions already recorded in the 'Proceedings of the Institution of Civil Engineers,' and in other publications, with reference to maritime and hydraulic engineering. It has, accordingly, appeared to me that the exceptional occasion of addressing a gathering of scientific persons, and of engineers who testify their interest in science by attending these meetings, would be best utilised by considering the relation that engineering in general, and maritime and hydraulic engineering in particular, bear to pure science, and the means by which progress in engineering science might be best promoted, and its scope and utility increased.

In addition to the oft-quoted definition of civil engineering as 'the art of directing the great sources of power in nature for the use and convenience of man,' Thomas Tredgold also defined it, in 1828, as 'that practical application of the most important principles of natural philosophy which has, in a considerable degree, realised the anticipations of Bacon and changed the aspect and state of affairs in the whole world.' If the influence of engineering could be thus described in 1828, when railways and steamships were in their infancy, and the electric telegraph and the various modern applications of electricity and magnetism had not come into existence, how far more true is it at the present day, when the various branches of engineering have attained such a marvellous development! Tredgold also realised, at that early date, that the resources of the engineer must be further directed so as to cope with the injurious forces of nature, such as floods, storms, and unsanitary conditions, and thus protect men from harm as well as promote their well-being. Moreover, he foresaw the great capabilities of development possessed by engineering, and its dependence on science; for he stated that 'the real extent to which civil engineering may be applied, is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors.' If the full significance of these statements may be accepted as correct, engineers might fairly claim to have a right to say, 'As engineers we are necessarily men of science, and no branch of science is outside our province.' It might, however, be said that no engineer, with his absorbing professional avocations, would have the time to acquire even the rudiments of the principal branches of science, with their ever-increasing developments, to the study of each of which the life-work of many earnest searchers into the secrets of nature is wholly devoted. Nevertheless, a few branches of science, such as physiology, biology, and botany, appear to be beyond the scope of practical engineering; whilst a moderate acquaintance with some others might suffice for the needs of the engineer, except in certain special branches, supplemented as it can readily be by the advice of a specialist in complicated cases.

Among the branches of science necessary for the engineer, two may be regarded as of the highest importance, namely, mathematics and physics, upon which the science of engineering mainly depends; and without an adequate knowledge of these no person should be able at the present day to enter the profession of a civil engineer. Other sciences of considerable, though of comparatively minor, importance to engineers in general, are chemistry, geology, and meteorology; but each of these assumes an enhanced value in special branches of engineering.

Mathematics in Relation to Engineering.—The pre-eminent importance of mathematics in relation to engineering may be accepted as fully established; and a President of the Institution of Civil Engineers would not now tell a pupil, at their first interview, that he had done very well without mathematics, a remark made to me by a justly celebrated engineer over thirty years ago.

Surveying, which is the handmaid of civil engineering, depends upon the principles of geometry for its accuracy; and ordinary triangulation, geodesy, and the rapid method of surveying and taking levels in rough country, known as tacheometry, are based on trigonometry and aided by logarithms. Tacheometry, indeed, though carried out by means of a specially constructed theodolite, may be regarded as the practical application of the familiar problem in trigonometry of finding the height and distance of an inaccessible tower. A proposition of Euclid forms the basis of the simplest and speediest method of setting out circular curves for railways; whilst astronomy has been resorted to for facilitating surveying in unexplored regions. The laws of statics are involved in the design of bridges, especially those of large span, and also of masonry dams, roofs, floors, columns, and other structures; whilst torsion, internal ballistics, the trajectory of a projectile, the forces of impact, and the stoppage of a railway train are dynamical problems. Hydrostatics and hydrodynamics provide the foundation of hydraulic engineering; though, owing to the complicated nature of the flow of water, observations and experiments have been necessary for obtaining correct formulæ of discharge. Geometrical optics has been employed for determining the forms of the lenses for giving a parallel direction to the rays proceeding from the lamps of a lighthouse, in accordance with the principles laid down by Fresnel. The theory of the tides, the tide tables giving the predicted tidal rise at the principal ports, and wave motion—questions of considerable importance to the harbour engineer—depend upon mathematical and astronomical calculations; whilst the stability and rolling of ships, the lines for a vessel of least resistance in passing through water, and the dimensions and form of screw-propellers, to obtain the greatest speed with a given expenditure of power, have been determined by mathematical considerations aided by experiment. Electrical engineering depends very largely upon mathematical and physical problems, guided by the results of practical experience; and the possibility of the commercial success of the first Atlantic cable, depending upon the rate of transmission of the signals and the loss of electrical intensity in that long journey, has been shown by Dr. John Hopkinson, in his 'James Forrest' lecture, to have been determined by Lord Kelvin by the solution of a partial differential equation.[1]

All branches of applied mathematics have, accordingly, been utilised by

[1] *Proceedings Inst. C.E.*, vol. 118, p. 339.

engineers, or, as in the case of several general principles and tidal calculations, by mathematicians to their benefit; but graphic statics will probably gradually supersede analytical methods for the calculation of stresses, as more rapid in operation, and less subject to errors, which are also more easily detected in graphic diagrams. Pure mathematics, in its higher branches, appears to have a less direct connection with engineering; but applied mathematics is so largely dependent upon pure mathematics, that the latter, including the calculus and differential equations, cannot be safely neglected by the engineer, though certain branches, as, for instance, probabilities, the theory of numbers, the tracing of curves, and some of the more abstruse portions of the subject, may be dispensed with.

Physics in Relation to Engineering.—Physics has been placed after mathematics, as many physical problems are determined by mathematics; but in several respects physics, with its very wide scope in its relation to the various properties of matter, is of equal importance to engineers, for there are few problems in engineering in which no part is borne by physical considerations.

The surveyor avails himself of physics when heights are measured by the barometer, or by the temperature at which water boils; and the spirit-level is a physical instrument adapted by the surveyor for levelling across land. Evaporation, condensation, and latent heat are of great importance in regard to the efficiency of steam-engines; and the expansive force of the gases generated or exploded, the diminution of friction, and the retention of the heat developed are essential elements in the economical working of heat-engines. Allowance for expansion by heat and contraction by cold has to be made in all large structures; and deflections due to changes in temperature have to be taken into account. The temperature, also, which decreases with the elevation above the sea-level, and the distance from the equator, limits the height to which railways can be carried without danger of blocking by snow; whilst the temperature, by increasing about 1° Fahr. with every sixty feet below the surface of the earth, limits the depth at which tunnels can be driven under high mountain ranges. Congelation of the soil is employed, as will be explained by Monsieur Gobert, in excavations through water-bearing strata.

Compressed air is used by engineers for excluding the water from subaqueous foundations, so that excavations can be made and foundations laid, at considerable depths below the water-level, with the same certainty as on dry land. The compression of air, and its subsequent absorption of heat on being liberated and expanding in a chamber, are employed for refrigerating the chambers in which meat and other perishable supplies are preserved. Compressed air is employed for working the boring machinery in driving long tunnels through rock, and provides, at the same time, means of ventilation; and it also serves to convey parcels along pneumatic underground tubes. Moreover, the compressed-air and vacuum brakes are the most efficient systems of automatic continuous brakes, which have done so much to promote safety in railway travelling, and in reducing the loss of time in the pulling up of frequently stopping trains. The production of a more perfect vacuum than can be produced by the ordinary air-pump, might have been supposed to be merely an interesting physical result;[1] but, in fact, the preservation of the heated filament of carbon in the incandescent electric light has been rendered possible only by the far more perfect vacuum obtained by the Sprengel vacuum-pump, by which the air is exhausted down to so low a pressure as one-two hundred millionth of an atmosphere.

The illuminating power of different sources of light is of great importance in determining the distance at which the concentrated rays from a lighthouse can be rendered visible, as well as in relation to the lighting of streets and houses; and the refrangibility of the rays emitted, or the nature of their spectrum, should not be disregarded, as upon this depends the power of a light to penetrate mist and fog, which cut off the rays at the violet end of the spectrum, and have comparatively little influence on the least refrangible red rays.[2] The effect also of the

[1] *Journal of the Chemical Society*, June 1864.
[2] *Proceedings Inst. C.E.*, vol. 57, pp. 145–148.

colouring of lights on their visibility is of interest in determining the shades of colour to be used for signals and ship-lights, and also the relative power of the lights required for different colours to secure equal illuminating power. Distinctions of colour are essential in these cases; but for distinguishing lighthouses the use of coloured glasses has been abandoned, on account of their impairing the light emitted; and the desired indication has been effected by varying the number and duration of the flashes and eclipses in each lighthouse. The detection of colour-blindness is of interest to engineers, as this physical infirmity incapacitates men from acting as engine-drivers, signalmen, or navigating seamen. The use of compressed oil-gas enables buoys and beacons to give a warning or guiding light for about three months without requiring attention; and the electric light has accelerated the passage through the Suez Canal from 30½ hours to 20 hours, and has greatly increased the capacity of the Canal for traffic by enabling navigation to be carried on at night. The electric light also affords an excellent, safe, and cool light in the confined cabins on board ship, in the headings of long tunnels, and in the working-chambers filled with compressed air used for sinking subaqueous foundations.

Acoustics might seem to have little relation to engineering; but the soundness of the wheels of a train are tested by the noise they give when struck with a hammer; warning notes are emitted by railway and steamship whistles, the fog-horn on board ship, and the whistling and bell buoys employed for marking shoals or the navigable channel; whilst the striking of bells, the blast of steam sirens, and the explosion of compressed gun-cotton cartridges and rockets indicate the position of lighthouses in foggy weather. The most powerful sounds that can be produced by the help of steam appear to have a very limited range as compared with light; for, under ordinary conditions, the most powerful siren ceases to be audible at a distance of six or seven miles; whilst the transmission of sound is very much affected by the wind and the condition of the atmosphere. It seems possible that loud detonations at short intervals may be more readily heard than the continuous blast of a steam trumpet.

Electrical engineering is very intimately connected with physics, for it really is the application of electricity to industrial purposes. The very close relation between electricity and magnetism, discovered by Oersted in 1820, and further established by the remarkable researches of Faraday, has led to the present system of generating electricity by the relative movement of coiled conductors and electro-magnets, in dynamo-electric machines worked by a steam-engine or other motive power. The electrical current thus generated can be transmitted to a distance with little loss of energy; and it can either be used directly for lighting by arc or incandescent lamps, or be reconverted into mechanical power by the intervention of another dynamo. Electricity is also employed for the simultaneous firing of a series of mines, at a safe distance from the site of the explosion.

The convertibility of heat and energy, indicated by Mayer, forms the basis of thermodynamics; and the mechanical equivalent of heat, a physical problem of the highest interest, determined by Joule in 1843, furnishes a measure of the amount of work that can be possibly obtained by a given expenditure of heat in heat-engines.

The above summary indicates how the discoveries of physics are applied to many branches of engineering; and a knowledge of the laws of physics, and of the results of physical researches, appears, therefore, essential for the successful prosecution of engineering works. The very intimate relation of mechanical science to mathematics and physics, and the indebtedness of engineers to men of science outside the ranks of their profession, are, indeed, evidenced by the roll of the Presidents of Section G, containing the names of Dr. Robinson, Mr. Babbage, Professor Willis, Professor Walker, and Lord Rosse.

Chemistry in Relation to Engineering.—Gas-making is in reality a chemical operation on a large scale, consisting in the destructive distillation of coal, the purification and collection of the resulting carburetted hydrogen, and the separation and utilisation of the residual products. Chemistry, accordingly, holds a very important place in the requirements of the gas engineer.

The manufacture of iron, steel, and other metals, and the formation of alloys, are essentially chemical operations; and the Bessemer and Gilchrist processes, by which steel is produced in large quantities directly from cast iron, by eliminating a portion of the carbon contained in it, and also the injurious impurities, silicon and phosphorus, in place of the former costly and circuitous method of removing the carbon from cast iron to form wrought iron, and then combining a smaller proportion of carbon with the wrought iron to form steel, are based on definite chemical changes, and necessitated chemical knowledge for their development.

Chemical analysis is needed for determining the purity of a supply of water, or the nature and extent of its contamination; and Dr. Clarke's process for softening hard water, by the addition of lime water, depends upon a chemical reaction. The methods also of purifying water by filtration, shaking up with scrap iron, and aëration, are chemical operations on an extensive scale; and their efficiency has to be ascertained by chemical tests.

Cements and mortars depend for their strength and tenacity, when mixed with water, upon their chemical composition and the chemical changes which occur. The value of Portland cement requires to be tested quite as much by a chemical analysis of its component parts, as by the direct tensile strength of its briquettes; for an apparently strong cement may contain the elements of its own disruption, in a moderate proportion of magnesia or in an excess of lime. The chemical change which has been found to occur in the Portland cement of very porous concrete exposed to the percolation of sea-water under considerable pressure, by the substitution of the magnesia in sea-water for the lime in the cement, if proved to take place even slowly under ordinary circumstances, would render the duration of the numerous sea works constructed with Portland cement very precarious, and necessitate the abandonment of this very convenient material by the maritime engineer.

Explosives, which have rendered such important services to engineers in the construction of works through rock and the blasting of reefs under water, as well as for purposes of attack and defence, form an important branch of chemical research. The uses of gun-cotton as an explosive agent, though not for guns, have been greatly extended by the investigations of Sir Frederick Abel, and by the discovery that it can be detonated, when wet and unconfined, by fulminate of mercury; whilst smokeless powder, a more recent chemical discovery, seems likely, by its application to firearms, to produce important modifications in the conditions of warfare. The progress achieved by chemists in other forms of explosives has been marked by their successive introduction for blasting in large engineering works. Thus the removal of the rock in driving the Mont Cenis tunnel, in 1857–71, was effected by ordinary blasting powder; whilst the excavation of the longer St. Gothard tunnel, in 1872–82, was accomplished by the more efficient explosive dynamite.[1] Moreover, the first great blast for removing the portion of Hallett's Reef which obstructed the approach to New York Harbour, was effected mainly by dynamite, together with vulcan powder and rendrock, in 1876; whereas the far larger Flood Rock, in mid-channel, was shattered in 1885 by rackarock, a mixture of potassium chlorate and nitrobenzol, and a much cheaper and a more efficient explosive under water than dynamite.[2] Rackarock is one of the series of safety explosives first investigated by Dr. Sprengel in 1870, which, consisting of a solid and a liquid, is safely and easily mixed for use; and these materials, being harmless previously to their admixture, can be stored in large quantities without risk.[3] The cost also of this large blast was greatly reduced by the sympathetic explosion of the bulk of the cartridges by the detonation of a series of primary exploders, placed at intervals along the galleries and fired simultaneously by electricity from the shore.

The utilisation of sewage belongs to agricultural chemistry; and the deodorisation of sewage, and its conversion into a commercial manure, are chemical processes.

[1] *Proceedings Inst. C.E.*, vol. 95, p. 266.
[2] *Ibid.*, vol. 85, pp. 267, 270.
[3] *Journal of the Chemical Society*, August 1873.

The disposal of sewage by irrigation is a branch of agriculture; and the innocuous character of the effluent fluid, discharged into the nearest stream or river, has to be ascertained by chemical analysis. Chemists have the opportunity of benefiting the community, and at the same time acquiring a fortune, by discovering an economical and efficient process for converting sewage on a large scale into a profitable saleable manure, so that inland towns may not have to dispose of their sewage at a loss, and that towns situated on tidal estuaries or the sea-coast may no longer discharge their sewage into the sea, but distribute it productively on the land.

The purifying of the atmosphere from smoke, rendered increasingly expedient by the growth of population, and the prevention of the dense fogs caused by it, by some practical method for more thoroughly consuming the solid particles of the fuel, still await the combined efforts of chemists and engineers.

Geology in Relation to Engineering.—A knowledge of the superficial strata of the earth is important for all underground works, and essential for the success of mining operations. Geology is indispensable in directing the search for coal, iron ore, and the various metals; and the existence of faults or other disturbances may greatly modify the conditions. The value of geology to the engineer is not, however, confined to the extraction of minerals, for it extends, more or less, to all works going below the surface.

The water-supply of a district, in the absence of a suitable river or stream, is dependent on the configuration and geology of the district; and the spread of London before the extension of waterworks, as pointed out by Professor Prestwich, had to be confined to the limits of the gravel subsoil, in which shallow wells gave access to the water arrested by the stratum of underlying London clay. The sinking also of deep wells for a supply of water, and the depth to which they should be carried, are determined by the nature of the formation, the position of faults, and the situation of the outcrop of the water-bearing stratum. A geological examination, moreover, of a site proposed for a reservoir, to be formed by a reservoir dam across a valley, has to be made to ascertain the absence of fissures and the soundness of the foundation for the dam.

In the driving of long tunnels, the nature and hardness of the strata and their dip, the prospects of slips, and the possibility of the influx of large volumes of water, are geological considerations which affect the designs and the estimates of cost. The excavations also of large railway cuttings and ship-canals are considerably affected, both as regards their side slopes and cost, by the nature and condition of the strata traversed.

Meteorology in Relation to Engineering.—The maximum pressure that may be exerted by the wind has to be allowed for in calculating the strains which roofs, bridges, and other structures are liable to have to bear in exposed situations; and continuous records of anemometers for long periods are required for determining this pressure. The force of the wind also, and the direction, duration, and period of occurrence of severe gales, are important to the maritime engineer for estimating the effects of the waves in any special locality, for determining the quarter from which shelter is needed, and for ascertaining the seasons most suitable for the execution of harbour works, the repair of damages, and the carrying out of foundations of lighthouses and beacons on exposed rocks. The harbour engineer must, indeed, of necessity be somewhat of a meteorologist, for the changes in the wind and weather, the oscillations of the barometer, and the signs of an approaching storm are indications to him of approaching danger to his works, which he has to guard against; for the sea is an insidious enemy which soon discovers any weak spot, and may in a few hours destroy the work of months.

Continuous records of rainfall, as collected regularly by Mr. Symons from numerous stations in the United Kingdom, are extremely valuable to engineers for calculating the probable average yield of water from a given catchment area, the greatest and least discharges of a river or stream, the size of drainage channel needed to secure a low-lying area from floods, and the amount of water available for storage or irrigation in a hot, arid district. The loss of water by evaporation at different periods of the year, and under different conditions of soil and climate, the effect of percolation in reducing evaporation, and the influence of forests and vegetation in increasing the available rainfall, while equalising the flow of streams, are subjects of equal interest to hydraulic engineers and meteorologists.

Countries periodically visited by hurricanes, cyclones, or earthquakes, necessitate special precautions, and special designs for structures; and every additional information as to the force and extent of these visitations of nature is of value in enabling engineers to provide more effectually against their ravages.

Benefits conferred by Engineering upon Pure Science.—Engineering is generally concerned in the application of the researches of science for the benefit of mankind, and not in the extension of the domain of pure science, which necessitates greater concentration of attention and study than the engineer in practice is able to devote to it. Engineers, however, though never able to repay the ever-increasing debt of gratitude which they owe to past and present investigators of science, except in rendering these abstract researches of practical utility, have, nevertheless, been able incidentally to promote the progress of science. Thus mechanical science, by the construction of calculating machines, the planimeter, integrating machines, the tide-predictor and tidal harmonic analyser of Lord Kelvin, the self-registering tide-gauge, and various other instruments, has lightened the labours of mathematicians; whilst excavations for works, and borings have assisted the investigations of geologists. The mechanical genius of Lord Rosse led mainly to the success of his gigantic telescope, which has revealed so many secrets of the heavens; and the rapidity of locomotion, due to the labours of engineers, has greatly facilitated astronomical observations and physical discoveries, besides promoting the concourse of scientific men and the diffusion of knowledge. Electrical engineering, moreover, is so closely allied to electrical physics that the development of the one necessarily promotes the progress of the other. The observations also conducted by hydraulic and maritime engineers in the course of their practice aid in extending the statistics upon which the science of meteorology is based.

Engineering as an Experimental Science.—Engineering, so far as it is based on mathematics, is an exact science, and the strains due to given loads on a structure can be accurately determined; but the strength of the materials employed has to be ascertained before any structure can be properly designed. Accordingly, the resistance of materials to tension, compression, and flexure, has to be tested, and their limit of elasticity and breaking weight determined. Thus, previously to the construction, by Robert Stephenson, of the Britannia Tubular Bridge, the first wrought-iron girder bridge of large span erected, numerous experiments on various forms of wrought iron were carried out by that eminent mathematician and mechanician Eaton Hodgkinson, who had previously indicated the proper theoretical form for cast-iron girders, and to whom the success of the bridge across the Menai Straits was in great measure due.[1] Besides the numerous tests always now made of the materials employed during the progress of any large engineering work, railway bridges are also subjected to severe test loads before being opened for public traffic, by which the safety of the structures and their rigidity, as measured by the amount of deflection, are ascertained, serving as a guide for subsequent designs.

Numberless experiments have been made on the flow of water in open channels, over weirs, through orifices, and along pipes; and the influences of the nature of the bed, the slope, depth, and size of channel, have been investigated by various hydraulicians. Mr. Thomas Stevenson measured the force of waves at some places on the Scotch coast;[2] Professor Osborne Reynolds has examined the laws of tidal flow in a model of the inner estuary of the Mersey, and in specially shaped experimental models;[3] and I have found it possible, in small working models of the Mersey and Seine, not merely to reproduce the configuration of the bed of the estuary out to sea, but also to observe the effects of different forms of training works in modifying sandy estuaries.[4] Mr. William Froude, after his retirement

[1] *The Britannia and Conway Tubular Bridges*, Edwin Clark, vol. 1, p. 83.
[2] *The Design and Construction of Harbours*, Thomas Stevenson, 3rd ed. pp. 52-56.
[3] *British Association Reports* for 1889, 1890, and 1891.
[4] *Proceedings of the Royal Society*, vol. 45, pp. 504-524, and plates 2-4; vol. 47.

from active practice, devoted his abilities to experiments on the motion and resistance of ships in water, which have proved of inestimable value to the naval architect, and which formed the subject of his presidential address to this Section in 1875.

Electrical engineering is specially adapted for experimental investigation; and, in this branch, theory and practice are so closely allied that some of the most eminent exponents of the theory of the subject, such as Lord Kelvin and Dr. Hopkinson, have developed their theories into practical results. In most other branches, the investigator is generally distinct from the engineer in large practice; but it may be safely said that an able investigator and generaliser in engineering science, as, for instance, the late Professor Rankine, accomplishes work of more value to the profession at large than the practical engineer, who, in the world's estimation, appears the more successful man.

Every branch of engineering science is more or less capable of being advanced by experimental investigations; and when it is borne in mind that the force of waves, the ebb and flow of tides in rivers, the influences of training works in estuaries, and the motion of ships at sea have been subjected to experimental research, it appears impossible to assign a limit to the range of experiments as a means of extending engineering knowledge. Problems of considerable interest, which can only be solved by experiments or by comprehensive generalisations from a number of examples, must frequently present themselves to engineers in the course of their practice, as they have to myself; and engineers would render a great service to the profession if they would follow up the lines of investigation thus suggested to them, in the true spirit of scientific inquiry.

Failures of Works due to Neglect of Scientific Considerations.—Before the amount and distribution of the stresses in structures were thoroughly understood, a disposition was naturally evinced to err on the side of excessive strength; and the materials in the various parts of the structure were not suitably proportioned to the load to be borne, resulting in a waste of materials and too great an expenditure on the works. Thus some of the early high masonry reservoir dams in Spain exhibit an excessive thickness towards the top, imposing an unnecessary load on the foundations; and in many of the earlier iron girder bridges more material was employed than was required for stability, and it was not properly distributed. Boldness engendered by increased experience, and dictated by motives of economy, has tended to make the engineers of the present day pursue an opposite course; and, under these circumstances, the correct calculation of the strains, the exact strength of the materials, and a strict appreciation of the physical laws affecting the designs become of the utmost importance.

The failures of many bridges may be explained by errors in design, defects in construction, or by economy carried beyond the limits of safety in pushing forward railways in undeveloped countries; but other failures are attributable to a disregard or underestimation of the influence of physical causes. Thus the Tay Bridge disaster, in 1879, was due to underestimating the amount and effect of the wind-pressure in an exposed situation, where it acted with a considerable leverage, owing to the height of the bridge, and was inadequately provided against by the small transverse width of the piers in proportion to their height, which were further weakened by bad workmanship in the bracing of their columns. The bursting of the Bouzy masonry dam in France this year must be attributed to an inadequate thickness at part of the cross-section, producing a tensional strain on the inner face with the reservoir full, aided by the instability resulting from a fissured foundation. The overthrow of the outer arms of the Madras breakwaters, during a cyclone in 1881, may be traced to an inadequate estimate of the force of the waves in a storm, in deep water, and with a great fetch across the Indian Ocean, beating against the portions of the breakwaters directly facing their course; for these outer portions, running nearly parallel to the coast-line, were not made any stronger than the inner portions

p. 142; and *Amélioration de la Partie Maritime des Fleuves, y compris leurs Embouchures*, L. F. Vernon-Harcourt, Paris Inland Navigation Congress, 1892, pp. 27-29 and 32, 33, and plate 3.

placed at right angles to the shore and the direction of the waves, and situated for the most part in shallower water. The erosion of the bed of the Ganges Canal on the first admission of the water, necessitating the erection of weirs at intervals to check the current, resulted from an error in the calculated discharge of the channel with the given inclination, and the consequent undue velocity of the stream, producing scour. The failure of the jetty works at the outlet of the Rhône to effect any permanent deepening of the channel over the bar, was due to the unsuitable direction given to the outlet channel in view of the physical conditions of the site, and the concentration of all the discharge, and consequently all the alluvium carried down, into a single mouth, whereby the rate of deposit in front of this outlet has been considerably increased. The excessive cost, and consequent stoppage, of the Panama Canal works, though due to a variety of causes, must be partly attributed to want of due consideration of the strata to be excavated; for a cutting of 300 feet in depth, which may be possible in rock, becomes impracticable when a considerable portion has to be executed in very treacherous clay.

Occasionally failures of works may be attributed to exceptional causes or peculiarly unfavourable conditions; but in most cases, as in the instances given above, they are the result of errors or deficiencies in design, which might have been avoided by a more correct appreciation of the physical conditions involved.

Scientific Training of Engineers.—In most professions, preliminary training in those branches of knowledge calculated to fit a student for the exercise of his profession is considered indispensably necessary; and examinations to test the proficiency of candidates have to be passed as a necessary qualification for admission into the Army, Navy, Church, Civil Service, and both branches of the law. Special care is taken in securing an adequate preliminary training in the case of persons to whom the health of individuals is to be entrusted, not merely by experience in hospitals, but also by examinations in those branches of science and practice relating to medicine and surgery, before the medical student can become a qualified practitioner. If so much caution is exercised in protecting individuals from being attended by doctors possessing insufficient knowledge of the rudiments of their profession, how much more necessary should it be to ensure that engineers are similarly qualified, to whom the safety and well-being of the community, as well as large responsibilities in regard to expenditure, are liable to be entrusted! The duty of the engineer is to apply the resources of nature and science to the material benefit and progress of mankind; and it, therefore, seems irrational that no guarantee should be provided that persons, before becoming engineers, should acquire some knowledge of natural laws, and of the principles of those sciences which form the basis of engineering. The Institution of Civil Engineers has, indeed, of recent years required some evidence of young men having received a good education before their admission into the student class; but some of the examinations accepted as sufficient for studentship, such as a degree in any British university, afford no certainty in themselves that the persons who have passed them possess any of the qualifications requisite for an engineer; and it is quite unnecessary to become a student of the Institution in order to become an engineer. The Council of the Institution has no doubt been hitherto deterred from proposing the establishment of an examination in mathematics and natural science, as a necessary preliminary to becoming an engineer, by the remembrance that some of the most distinguished engineers of early days in this country were self-taught men; but since those days engineering and the sciences upon which it is based have made marvellous advances; and in view of these developments, and the excellent theoretical training given to foreign engineers, it is essential that British engineers, if they desire to retain their present position in the world, should arrange that the recruits to their profession may be amply qualified at their entrance in theoretical knowledge, in order to preserve the standard attained, and to be in a position to achieve further progress. No amount of preliminary training will, indeed, necessarily secure the success of an engineer, any more than the greatest proficiency would be certain to lead the medical student to renown as a physician or surgeon; but other conditions being equal, it will greatly promote his prospects of advancement in his profession, and his utility to his colleagues and the public. The engineers of the past achieved great results in the then early dawn of engineering knowledge, by sound common sense, a ready grasp of first principles and of the essential points of a question, capacity for acquiring knowledge, power of managing men and impressing them with confidence, and shrewdness in selecting competent assistants. These same qualities are still needed for success in the present day, coupled with an opportunity of exhibiting them; but far more knowledge of mathematics and other sciences is required now, owing to the enormous advances effected, if the progress of engineering science is to be maintained. Even though in some branches engineers in large practice may not have the time, or retain the requisite facility, for solving intricate mathematical problems, they should be able readily to comprehend the full bearing of the principles presented, and to understand the nature of the solutions put before them, which nothing but the scientific faculty implanted by early training in mathematics and physics can adequately secure.

A qualifying examination for engineers would usefully stop persons at the outset from entering the profession, who failed to evince the possession of the requisite preliminary knowledge: it would indicate, by the subjects selected, the kind of training best calculated to fit a person to become a useful engineer; and it would protect the public, as far as practicable, from the injuries or waste of money that might result from the mistakes of ill-qualified engineers.

Specialising in Engineering.—Some branches of engineering have for a long time been kept distinct from others, such as the construction of steam-engines, locomotives, and marine engines, ship-building, heavy ordnance, hydraulic machinery, and other purely mechanical works, one or more of which have been treated as specialities by certain firms, and also gas lighting, and, more recently, electric lighting. In the department, however, of civil engineering in its narrower signification, as distinguished from mechanical engineering, engineers of former times were regarded as equally qualified to undertake any of the branches of public works; and the same engineer might be entrusted with the execution of roads, railways, canals, harbours, docks, sewerage works, and waterworks; while even steamships were not excluded from the category in Brunel's practice. The engineer of to-day, indeed, would be lacking that important factor for success, common sense, if he declined to execute any class of works which he might be asked to undertake; and a variety of works is very useful to the engineer in enlarging his views and experience, as well as in extending the range of his practice. The tendency, however, now in engineering, as in medicine, is for the engineer's practice to be confined to the special branch in which he had had most experience; a result which cannot fail to be beneficial to the public, and calculated to promote the progress of each branch. The powers of the human mind are too limited, and life is too short, for engineers to be able to acquire, in the present day, equal proficiency in the theory and practice of the several branches of engineering science, with their ever-widening scope and development; and, as in the domain of abstract science. general progress will be best achieved in engineering science by the concentration of the energies of engineers in the advancement of their special line of practice.

Value of Congresses on Special Branches of Engineering.—The scope of engineering science is extending so fast that it is impossible for the Institution of Civil Engineers, which, as the parent society, embraces every branch within its range of subjects, to give more than a very limited time for the consideration and discussion of papers relating to the non-mechanical branches of the profession comprised in public works. Mechanical, electrical, and gas engineers have special societies of their own for advancing their knowledge and publishing their views and experience, while sharing equally with the other branches in the benefits of the older Institution. Congresses accordingly afford a valuable opportunity for railway, hydraulic, and sanitary engineers of expressing their views, and enlarging their experience by consultation and discussion with engineers of various countries. My experience of the six maritime, inland navigation, and waterworks international congresses I have attended in England and abroad, has convinced me of the very great value of such meetings in collecting information, comparing views, and obtaining some knowledge of foreign works and methods; whilst the acquaintances formed with some of the most celebrated foreign engineers, afford opportunities of gaining further information about works abroad, and deriving experience from their progress and results.

Engineering Literature.—Lawyers have been defined as persons who do not possess a knowledge of law, but who know where to find the law which they may require. It may be hoped that a similar definition is not applicable to engineers; but with the rapid increase of engineering literature, it is most desirable that engineers should be able readily to refer to the information on any special subject, or descriptions of any executed works, which may have been published. Much valuable matter, however, is buried in the proceedings of engineering and scientific societies, and in various publications; and often a considerable amount of time is expended in fruitless search. This great waste of time and energy, and the loss of available information involved, led me a few years ago to suggest that a catalogue of engineering literature ought to be made, arranging the lists of publications relating to the several branches under separate headings. There is a possibility that this arduous and costly task may be partially accomplished in separate volumes; and, at any rate, the first step has been effected by the publication, under the auspices of the Paris Inland Navigation Congress of 1892, of a catalogue of the publications on inland navigation. A start has also been made in France, Italy, and England, towards the preparation of a similar catalogue on maritime works, which it may be hoped means will one day be found to publish on the meeting of some future congress. Engineers who have searched, even in the best libraries, for the published information on any special subject, will appreciate what a great boon an engineering subject catalogue would be to the profession, and indirectly to the public at large.

The occasional publication of comprehensive books on special branches of engineering, and concise papers on special subjects, by competent authorities, are extremely valuable in advancing and systematising engineering knowledge; but the time and trouble involved in the preparation of such publications must, like the organising of congresses, be regarded as a duty performed in the interests of the profession and science, and not as affording a prospect of any pecuniary benefit.

Concluding Remarks.—In this address, I have endeavoured, though very imperfectly, to indicate how engineering consists in the application of natural laws and the researches of science for the benefit and advancement of mankind, and to point out that increased knowledge will be constantly needed to keep pace with, and to carry on, the progress that has been made. The great advantages provided by engineering works in facilitating communications and intercourse, and consequently the diffusion of knowledge, in increasing trade, in extending civilisation to remote regions, in multiplying the comforts of life, and affording enlarged possibilities of enjoyment and change of scene, may be regarded as amply acknowledged; but the more gradual and less obvious, though not less important, benefits effected by engineering works are not so fully realised.

A comparison of engineering with the other chief branch of applied science, medicine, exhibits some similarities and differences. In both professions, the discoveries of science are utilised on behalf of mankind; but whilst physicians devote themselves mainly to individuals, engineers are concerned in promoting the well-being of the community at large. Persons reluctantly consult doctors when they are attacked by disease, or incapacitated by an accident; but they eagerly resort for enjoyment to railways, steamships, mountain tramways, piers, great wheels, and Eiffel towers; and they frequently avail themselves of the means of cheap and easy locomotion to complete their restoration to health by change of air and climate. Physicians try to cure people when they are ill; whereas engineers endeavour, by good water-supply and efficient drainage, to maintain them in health; and in this respect, the evident results of medical skill are far more readily realised than the invisible, though more widespread, preventive benefits of engineering works. Statistics alone can reveal the silent operations of sanitary works; and probably no better evidence could be given of the inestimable value of good water and proper drainage on the health of the population of large towns, when aided by the progress of medical science, than the case of London, where, towards the close of the last century, the death-rate exceeded the birth-rate, and the numbers were only kept up by constant immigrations; whereas now, in spite of the vast increase of the population and the progressive absorption of the adjacent country into the ever-widening circle of houses, the number of births exceed the deaths by nearly nine hundred a week.

In engineering, as in pure science, it is impossible to stand still; and engineers require to be ever learning, ever seeking, to appreciate more fully the laws of nature and the revelations of science, ever endeavouring to perfect their methods by the light of fresh discoveries, and ever striving to make past experience and a wider knowledge stepping-stones to greater achievements. Engineers have a noble vocation, and should aim at attaining a lofty ideal; and, in the spirit of the celebrated scientific discoverers of the past, such as Galileo, Newton, La Place, Cavendish, Lyell, and Faraday, should regard their profession, not so much as an opportunity of gaining a pecuniary reward, as a means of advancing knowledge, health, and prosperity.

The remarkable triumphs of engineering have been due to the patient and long-continued researches of successive generations of mathematicians, physicists, and other scientific investigators; and it is by the utilisation of these stores of knowledge and experience that engineers have acquired renown. A higher tribute of gratitude should perhaps be paid to the noble band of scientific investigators who, in pursuit of knowledge for its own sake, have rendered possible the achievements of engineering, than to those who have made use of their discoveries for the attainment of practical benefits; but they must both be regarded as co-workers in the promotion of the welfare of mankind. The advancement of science develops the intellectual faculties of nations, and enlarges their range; whilst the resulting progress in engineering increases their material comforts and prosperity. If men of science, by closer intercourse with engineers, could realise more fully the practical capabilities of their researches, and engineers, by a more complete scientific training, could gain a clearer insight into the scientific aspect of their profession, both might be able to co-operate more thoroughly in developing the resources of nature, and in furthering the intellectual and material progress of the human race.

The following Papers were read:—

1. *Light Railways as an Assistance to Agriculture.* *By* MAJOR-GENERAL WEBBER, *C.B.*, *R.E.*, *M.Inst.C.E.*

The great impetus given to a possible extension of light railways in the United Kingdom through the assembly of representatives of various interests connected with the subject by the Board of Trade in December last has not borne any fruit.

To this committee Lieut.-Colonel Addison, R.E., and Mr. Stovin Warburton, our Consul at Rochelle, both made admirable reports on the subject of light railways, the one dealing with Belgium, the other with Western France.

The so-called *light railways* of Ireland, constructed under Government and baronial guarantees, have no analogy either in their engineering or working with the lines with which the author seeks to familiarise the Section.

One of the most useful lessons to be learnt from the examples described, both home and foreign, is the ease and safety with which light railways can be worked alongside and on public roads, both in the country and through the towns, even when they are crowded as Ipswich is on a busy day.

The author's object in bringing the question before what it is hoped may be a Suffolk audience fully acquainted with agriculture is to get up discussion on how far what is practicable will really be remunerative on the capital to be expended, and will lessen the cost of transport between producer and consumer.

It has been assumed that in a county such as Suffolk there is use for 200 miles of such light railway, with the suggestion that this length would be distributed in twenty directions, each line having an average length of 10 miles.

The gauge throughout to be 24 inches, and the lines to be provided with a *turnout* alongside of each holding of a certain size, and at each place where an agricultural industry such as dairying is established. Stations, means of warehousing, and workshops to be provided only in the proportion of one to each line, all stopping places to require but trifling expenditure.

The rolling stock in proportion to each line to be—

2 steam locomotives;
2 composite carriages;
2 break vans;
2 timber waggons;
5 covered waggons;
20 goods waggons, of sorts.

The total capital cost, if undertaken on such a moderate scale, would be 287,105*l.*, or 1,436*l.* per mile.

The estimate of total takings, allowing one mixed train each way per diem only, or one all-round journey, and also allowing that one-fourth the capacity for goods is only used, is .	£10,300
For passengers, one-fourth the capacity of the first-class, and one-half of the third-class accommodation being used . .	8,214
Total	£18,514

With 247,200 train lines per annum this gives 1*s.* 6*d.* a mile.

There are many examples to show that the running cost, providing for upkeep and renewals, can be kept within 1*s.* a mile, leaving a nett profit of	£6,180
The nett receipts for mails, parcel, excursions, and advertising work out at	1,782
Total nett revenue	£7,962

or about 2*l.* 18*s.* per cent.

Extra nett revenue would be derived with extra mileage run, and it might be expected that two all-round journeys would before long be necessary on several lines.

The author omits the question of the purchase of land. Parliament proposes that the public inquiries preliminary to these light railways shall be essentially local. The views as regards compensation and the necessity of buying land will be governed by considerations which will be local in every respect; and if it is in the interests of the locality generally that their expenditure be kept at a minimum, they need not at most exceed 100*l.* a mile, or 20,000*l.* altogether.

The burthen of the guarantee of this fund I propose shall be the only one to be taken by the County Council, and when that is realised, I think individual interests will receive no unfair share of consideration.

At 4 per cent., including a sinking fund, this may at first throw 800*l.* a year on the rates, but it will soon be earned. In return, the local authority to have a deferred charge on the earnings, and powers to become sole proprietors at the end of a term of years, and in the meantime to be represented on the board of direction.

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2. *The Gobert Freezing Process for Shaft-sinking and Tunnelling under Rivers. By* A. GOBERT, *Ingénieur Civil of Brussels.*

The process consists in freezing water-bearing strata and running sands by means of liquid ammonia poured straight into the freezing-pipes, which are sunk vertically into the ground which is to be frozen. The liquid ammonia, in passing into gas in the freezing-pipes, produces a more intense cold than that obtained by unfreezable liquids, which are themselves rendered cold by the evaporation of ammonia. By adopting direct evaporation, the danger is avoided of rendering the ground unfreezable in the event of the escape of the unfreezable liquid; the cost of the installation is reduced by dispensing with the unfreezable liquid, and with the apparatus used for rendering it cold; and the power of the refrigerating machine is much better utilised. The process possesses the advantage of being able to freeze the bottom without freezing the upper layers. Thus, when it is necessary to deepen the lined shaft of a mine which has been flooded, the freezing-pipes can be placed inside the lining, without any risk of bursting the lining by the freezing of the water which is inside it. In the case of tunnelling under a river, as the evaporation of the ammonia takes place below the water-level, hardly any of the cold is lost in the contact of the pipes with the water; whereas a great quantity would be lost in employing an unfreezable liquid.

3. *East Anglian Coal Exploration, Description of Machinery Employed. By* J. VIVIAN.

4. *The Effect of Wind, and Atmospheric Pressure on the Tides. By* W. H. WHEELER, *M.Inst.C.E.*

In this paper it is shown that while a general rule, founded on observations made by Sir J. W. Lubbock, as to the effect of atmospheric pressure in raising or depressing the height of the tides has been formulated, no attempt has yet been made to deduce any law as to the more important effect of gales of wind; and shows that the subject is one of considerable importance to navigation, especially to pilots and captains of coasting vessels, who frequently have to cross over bars and shoals in navigable channels with a very narrow margin of water under the keel, while tides are frequently raised or depressed to the extent of several feet by gales.

In the author's opinion the use of the barometer cannot be made of service in predicting the condition of the tide, as the pressure varies on different parts of the coast, and in order to calculate its effect on the tide the direction of the gradient of pressure and the locality of high and low pressure must first be known. This can only be ascertained by consulting the weather charts issued from the meteorological office. This source of information is not available on board ship or at many of the smaller ports. A rapid alteration in the pressure of the atmosphere is almost always accompanied by wind, which affords a more ready and reliable guide for the immediate purposes of navigation.

From an analysis of two years' tides at the Port of Boston, and excluding occasions when the element of wind would affect the case, the author found that out of 152 observations, 61 gave an opposite result to that which would have been expected; a high barometer frequently being accompanied by a high tide, and a low barometer by a low tide.

On the other hand, with few exceptions, it is found by experience that when the wind blows with any force along a coast in the same direction as the main stream of the flood tide, the tides at all the ports along that coast will be higher than the calculated height given in the tide tables; and when the wind blows against the flood tide, high water will be lower than calculated.

The author gives numerous instances of the effect of gales in raising and lowering the natural height of the tides, and tables showing the effect of the gales of November 1893 and 1894 on the tides at the principal ports round the coast of Great Britain. These figures show that the variation is on some occasions as much as from 5 to 6 feet, and the difference in the height between two succeeding tides as much as 8 feet.

From an analysis of the register of tides at Boston Dock on the East coast over two years, the author found that 24 per cent. of the whole tides recorded were sufficiently affected by the wind as to vary 6 inches from the calculated height; thirty varied by 2 feet, seven by 3 feet, six by 3½ feet, three by 4 feet, two by 4½ feet, one by over 5 feet, and one by 6 feet 3 inches.

From these tides, checked by comparison with those at other parts of the coast, the author has formulated a table showing the amount to be added to or deducted from the height of the tide of the day as given in the tide tables, according to the strength and direction of the wind:—

Approximately it may be taken that with a given force of wind of 3 on the Beaufort scale a tide will be raised or depressed by half an inch for every foot of range; with a force of from 4 to 6 the variation may be expected to be 1 inch for every foot; with a gale of from 7 to 8, $1\frac{1}{2}$ inch; and if the gale increases to 10, then 2 inches. For example, supposing the rise of a Spring tide at any particular port to be 16 feet above low water, and the wind to be blowing with a force of 5, then 16 multiplied by one inch would make that tide 16 inches higher, or 17 feet 4 inches.

It is not intended that any absolute reliance can be placed on the formula, but that it may be taken as a sufficiently approximate guide by which pilots or captains of coasting vessels may be able to form some estimate as to the extent to which the tide will be affected, and consequently the depth of water available over bars or shoals.

FRIDAY, SEPTEMBER 13.

The following Papers were read:—

1. *Notes on Autumn Floods of* 1894. *By* G. J. Symons, *F.R.S.*

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2. *On Weirs in Rivers.* *By* R. C. Napier, *and* F. G. M. Stoney.

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3. *An Experiment in Organ-blowing.* *By* W. Anderson, *C.B., D.C.L., F.R.S.*

An organ of sixty-one stops and four manuals at the Goldsmiths' Technical and Recreation Institute, New Cross, London, was found defective in its blowing apparatus. Sir Frederick Bramwell, Bart., LL.D., F.R.S., and the author, governors of the Institute, were requested to look into the matter, and finding that the maximum pressure required was only 10 inches of water, determined to adopt an ordinary smiths' fan, driven by an electric motor specially wound and coupled direct to the fan spindle. Some preliminary experiments showed that a fan with a 10-inch outlet and a six bladed 25-inch impeller, driven at about 1,900 revolutions per minute, was amply competent to give the pressure and volume of wind required. Some apprehension was felt lest the pulses due to the fan might interfere with the lower notes of the organ, but exhaustive trials have shown that no such interference takes place.

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4. *The Growth of the Port of Harwich.* *By* W. Birt.

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5. *The new Outlet of the River Maas at the Hook of Holland, and the Improvement of the Scheur Branch up to Rotterdam.* *By* L. F. Vernon Harcourt, *M.A., M.Inst.C.E.*

The gradual shoaling of the mouths of the Maas, coupled with the increasing draught given to sea-going vessels, rendered the access to Rotterdam inadequate in the first half of this century. An attempt was made to obtain a deeper entrance than existed at the mouth of the new Maas by the construction of the Vonne Canal in 1827–29, enabling vessels to enter by a somewhat deeper mouth to the south; but the available depth over the bar of this mouth was often only 12 feet, and under the most favourable conditions vessels drawing more than 17½ feet could not go up to Rotterdam, and even then the route was very circuitous, and the journey occupied at least eighteen hours. In 1858 Mr. Caland proposed cutting a new direct outlet for the Scheur branch of the Maas across the Hook of Holland, continued across the foreshore into deep water by fascine-work jetties, and this scheme was approved and commenced in 1863. The north jetty was carried out in 1863–74 to a length of 2,187 yards, and the south jetty in 1864–76 for 2,515 yards; the channel across the Hook was excavated, 164 feet wide and 10 feet deep, in 1868–71; and the old outlet to the south of the Hook was closed by a dam in 1872. The new channel was first used by fishing vessels in 1871 and by steamers in 1872. The river was also regulated by training works, in a gradually widening channel, from Rotterdam to the Hook. The scour, which had been relied upon for widening the cut and deepening the channel across the foreshore between the jetties, proved inadequate to accomplish this, and accordingly in 1882 the widening of the narrow cut by excavation and the deepening of the jetty channel by dredging, and its narrowing 656 feet by a low training bend to the south, were commenced. The river above has also been further regulated and deepened by training and dredging, and the escape of the ebb tide into the old Maas has been prevented by the contraction of the entrance to the junction channel. By these works the river has been made to widen out uniformly from 330 yards at Rotterdam to 765 yards at the ends of the jetties; and not only has the navigable channel been widened and deepened, but the flow has been rendered uniform and the tidal scour has been increased.

The minimum depth at low tide between the jetties and in front has gradually been increased from 10 feet in 1882 up to 26¼ feet in 1893, and the rise of tide adds about 5½ feet. The maximum draught of the vessels navigating the new channel has increased from 19⅓ feet in 1882 up to 25 feet in 1893; and the number of vessels drawing 23 feet and over has risen from 16 in 1886 up to 150 in 1893. Vessels can now reach Rotterdam from the sea in two hours; and the total number of vessels using this new channel has increased from 6,946 in 1879, with a capacity of 8,314,000 cubic metres, up to 9,628 in 1893, with a capacity of 20,432,000 cubic metres.

Before the construction of the Moerdyk bridge, about twenty years ago, and the extension of the railway to Rotterdam, passengers from England to Rotterdam and Amsterdam had to go by Ostend and Antwerp, and by steamer from Moerdyk to Rotterdam; and even after the completion of the railway the journey was a long and circuitous one. Rotterdam also, thirty years ago, was a small town and a somewhat insignificant port. The new deepened outlet and the extension of the railway from Schiedam to the Hook, together with the improved accommodation provided at Harwich, has opened a short cheap route to North Holland, and also to the Continent beyond. The improvement, moreover, of the river has transformed Rotterdam into a large port; large basins surrounded by quays have been found opening into the river, in addition to quays along the river; and considerable extension works are in progress for providing further accommodation for vessels and the rapidly growing trade of the port. Having travelled to Rotterdam in 1865 and 1867 by the old route, by railway from Antwerp in 1880, and down the river from Rotterdam to the outlet, and last year from Harwich to the Hook, and also both up and down the river and through the port, I have myself had an opportunity of witnessing the marvellous development of Rotterdam and the changes which the works since 1882 have made in the river between Rotterdam and the sea.

The total cost of the river works, up to their completion this year, has amounted to about 2,950,000*l.*

6. *The Snowdon Mountain Tramroad.*
By F. OSWELL, *Assoc.M.Inst.C.E.*

The idea of a railway up Snowdon was first suggested as long ago as 1871 when the late Sir Richard Moon, at the opening of the Llanberis-Carnarvon Railway, referred to the possibility of such an undertaking. Several attempts made since that time to set it on foot have failed, but in November last year the necessary arrangements were made with the landowner, and the works were begun in the middle of December.

The line is set out with a special regard to the tenants' interests, at the same time to secure, wherever possible, the finest views for the passengers consistent with easy gradients and light earthworks.

Leaving the Llanberis Station, which stands on the main road, midway between the L. & N.W. Station and the Victoria Hotel, the line follows the stream as far as Cae Esgob, where it crosses it in front of the old King's House, passes near the Methodist Chapel (Hebron) on the left, and at two miles reaches and crosses the bridle path by a bridge. The first half-way house is passed 60 feet, and the second 180 feet below, the tramroad at this point arriving on the watershed which it follows for half a mile, and crossing the bridle path again at $3\frac{1}{2}$ miles, 2,550 feet above the sea, remains below it (at one point as much as 200 feet below) until $4\frac{1}{4}$ miles, when path and tramroad run nearly side by side to the summit, terminating at the site of the hotel that is to be built here, 3,500 feet above the sea, and 50 feet below the plateau where the present huts stand. Here a fine view is obtained over the Bwlch Main Watershed towards Beddgelert, as well as in other directions.

The length of the line is $4\frac{5}{8}$ miles, the total rise 3,140 feet, the steepest gradient 1 : 5·5; the average gradient 1 : 7·83. Two miles of the entire length are in curves, of which there are thirty-four in all, with radii of 4, 5, 10, 12, and 20 chains. There are to be terminal stations at the top and bottom, three intermediate equidistant passing places, and an additional station at the waterfall (Cenwant Mawr).

The works consist chiefly of a viaduct 500 feet long, near the beginning of the line, composed of fourteen brick arches 30 feet span carried on masonry pier a second viaduct of four similar arches crossing the side of the waterfall ravine, an arched bridge of 50 feet span over the stream, and five smaller bridges.

The permanent way is all of steel, the rails being of the Indian State Railways pattern, $41\frac{1}{4}$ lb. to the yard, 9 metres long, carried on rolled steel sleepers, to which they are attached by clips and bolts. The sleepers are spaced throughout 0·90 metre apart, and the fish plates are 3 ft. 6 in. long, with slots in the ends to admit the clip of adjacent sleepers, each pair carrying six fish bolts.

The rack is of the 'Abt' pattern and laid double throughout, the bars being 1·80 metre long, spanning two sleepers and breaking joint with each other. They are $\frac{4}{5}$ inch thick on grades of 1 : 10 or flatter, and 1 inch thick on all steeper grades. They are carried on rolled and milled steel chairs, which are attached by heavy bolts to the sleepers.

The locomotives have been built at Winterthur in Switzerland with the object of saving delay, and they contain all the latest improvements known for this class of engine. They carry two double differentiating pinion wheels on the axles of the 'driving' wheels, which latter run free on the axles, so that the engine cannot travel on adhesion rails alone.

There are two cylinders 12 in. diameter by 24 in. stroke; the rigid wheel base is 4 ft. 5 in. There is a third axle carrying trailing wheels under the cab.

There are eight break blocks, four to each pinion. These breaks may be worked by hand, but are applied automatically by steam power if a certain fixed rate of speed is exceeded.

There is also an air-break, worked in conjunction with the hand-break in descending, which retards or arrests the motion by forcing air into the backs of the cylinders after steam has been cut off.

All the permanent way material has been made by English firms. The engineers to the undertaking are Messrs. Sir Douglas Fox & Francis Fox, London. The contractors are Messrs. Holme & King, Liverpool. The author is the Resident Engineer.

SATURDAY, SEPTEMBER 14.

The following Reports and Papers were read :—

1. *First Report on Standardising.*—See Reports, p. 497.

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2. *Report on Coast Erosion.*—See Reports, p. 352.

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3. *Dredging Operations on the Mersey Bar.* *By* Anthony George Lyster, *M.Inst.C.E.*

The paper commences with a short account of the physical and geographical features of the river Mersey, tracing its course from the junction of the Goyt with the Etherow, near Stockport, to the mouth of the river.

A more detailed description is given of the course of the river where it enters Liverpool Bay, and the form and character of the main channel are explained.

The bar is next considered, its former condition described, and the positions of the main channel and of the bar at the outlet of the main channel are shown to be by no means permanent, but to have both altered considerably within quite recent times.

The great inconvenience of the bar as a cause of delay to modern navigation is discussed and the urgent necessity for amelioration is shown.

Dredgings operations which have been undertaken at New York and at the mouth of the Mississippi are then touched upon, and a comparison is made between the work done at these places and that in progress at the Mersey Bar.

After describing the position of the dredged cut, which is also shown by diagrams, an account is given of two steam hopper barges which were first fitted up with sand pumps and used for the purpose of dredging a deep cut across the Mersey Bar, their capacities, rates of loading, suction tubes, hoppers, and general characteristics are fully described, as is also the variable nature of the material which they are engaged in removing.

An account of the quantity of material removed by these dredgers is then given and a description of the new and more powerful dredger, the 'Brancker,' which was built in consequence of the successful results achieved by the smaller ones, is entered upon.

With regard to the 'Brancker' the form and dimensions, fittings, contract conditions, work done, and the proportion of the whole time available for working are fully dealt with.

The fitting up of the steam tender the 'Alarm' as an 'eroder,' with the object of dealing exclusively with the fine mud on the outer face of the bar on ebb tides, is next described.

The material found on the bar is then analysed. Sections taken across the bar in 1890, 1893, and 1895 are compared, and an account is given of observations of the rate of flow of neap and spring tides both previous to and during the present operations, while the paper closes with an expression of the author's views on the general theory of the formation of river bars, and the advisability of further increase of the dredging plant.

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4. *On Carbonic Anhydride Refrigerating Machinery.* *By* E. Hesketh.

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5. *On the Deodorising of Sewage by the Hermite Process.* *By* J. Napier, *F.C.S., Public Analyst for County of Suffolk.*

This process consists of passing an electric current obtained from a dynamo through sea water or a solution containing magnesium and sodium chlorides, whereby a portion of the chlorides is converted into hypochlorite, a substance which disinfects, deodorises, and bleaches similarly to the active ingredient of bleaching powder, viz., calcium hypochlorite. This solution is called the electrolised or 'hermite' solution, and may contain from half to one gramme of active chlorine per litre.

The author gives a brief history of the sewering of Ipswich during the last twenty years, showing the present system, particularly the position of the main sewer as it passes through the town to the outfall.

The deodorising effects of the electrolised (hermite) solution on sewage, especially upon that in the main sewer of Ipswich, are dealt with, and the results of trials made in August and September 1894 and in June, July, and August of this year are given.

The installation was at full work during the meeting of the Association. Those interested in the electrolysis of sea water and its effects on sewage were invited to visit the works.

MONDAY, SEPTEMBER 16.

The following Papers were read :—

1 *The Modern Application of Electricity to Traction Purposes.* *By* Philip Dawson.

Introductory.—Sketch of progress made during the past decade; introduction of the under-running trolley and earth return; adoption of electrical motive power by the West End Street Railway of Boston, U.S.A., in 1888; in 1890, 2,523 miles of electric tramways in America; rapid increase in mileage and equipment in the United States; statistics and financial statement; first prominently successful line in Europe at Halle, Germany, in 1891; statement of present European installations and of electrical tramway construction now under contract.

General and Descriptive.—The especial adaptability of electric traction to tramways and light railways; but three methods of electrical power transmission practically employed: (1) by elevated conductors with trolley contact; (2) by subsurface conduit—contained conductors—and (3) by surface or third rail conductors; the former by far the most efficient and successful and in most extensive use; objections to the overhead wire and compensating advantages.

Parts of an Electric Tramway Installation.—Latest machinery apparatus and methods of construction.

(*a*) *Power, Plant.*—Approved engines, dynamos, and accessories; general use of compound-wound machines; direct coupled generators for large units; importance of automatic circuit breakers; power required; reserve; utilisation of accumulators.

(*b*) *Motors and Gearing.*—Specific requirements for exacting service; general design; results of tests.

(*c*) *Regulation and Control.*—Construction and operation of the series parallel controller; its economy as contrasted with former methods; speed regulation.

(*d*) *Motor Trucks.*—Essential points of construction; four-wheel, bogie, and radial trucks; safety appliances; brakes, fenders, sand-boxes, lightning arresters, &c.

(*e*) *Trolleys.*—For cars with and without roof seats, and for varying methods of trolley-wire suspension; wheel and scraping contacts; modern pivotal trolleys.

(*f*) *Overhead Line.*—Description of material employed; poles, trolley-wire, insulators, span-wire, lightning arresters, &c.; methods of suspension adopted on British and Continental lines; feeders; double-conductor construction.

(*g*) *Return Circuit.*—Its importance; supplementary return feeders; bonds and method of bonding; electric welding.

Notable Installations.—European and American; three-phase at Dublin, Sacramento, and Portland; three-wire system; water-power; 'light railway,' mining, and other services.

Application to Railway Service.—City and South London Railway; Liverpool overhead; Chicago and New York Elevated Railways; branch lines and suburban service in connection with steam lines; Baltimore and Ohio Railway Company's 95-ton locomotives.

Conclusion.—Economic results already attained; probable extension and development.

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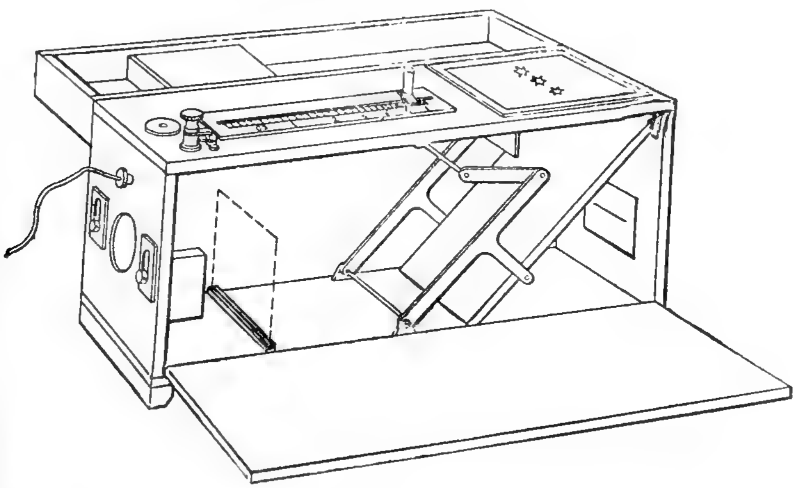
2. *An Improved Portable Photometer.*[1]

By W. H. Preece, *C.B.*, *F.R.S.*, *and* A. P. Trotter, *B.A.*, *A.M.I.C.E.*

The authors begin by defining what is meant by illumination. When light falls upon a surface that surface is said to be illuminated. The illumination depends simply upon the light falling on the surface, and has nothing to do with



the reflecting power of the surface, just as rainfall is independent of the nature of the soil. It depends also on the cosine of the angle of incidence. The lighting of streets and of buildings may be specified by the maximum and minimum illumination. The primary purpose of an illumination photometer is to measure the resulting illumination produced by any arrangements of lamps irrespective of their number, their height, or their candle-power.

The authors allude to the illumination photometers of Weber[2] and Mascart,[3] Preece's first photometer,[4] the authors' modification,[5] and Trotter's further modification,[6] which was used for measurements and photometrical surveys of streets and public buildings in London, 1892. The new instrument (see figure above) is a box, on the upper surface of which is a diaphragm of white card painted with a whitewash of magnesia and isinglass. It has one or more star-shaped perforations.

[1] Published in full in the *Electrician*, September 20, 1895.
[2] *Elec. Zeit.* 1884, p. 166.
[3] *Bull. de la Soc. Inst. des Elec.* 1888, p. 103.
[4] *Proc. Roy. Soc.* xxxv. p. 39, 1883.
[5] *Proc. Inst.* 3, 8, cx. p. 101.
[6] *Proc. Inst. C.E.* cx. p. 105.

Immediately below it, within the box, is a white screen capable of adjustment at different angles and two small electric lamps of different candle-power, either or both of which can be used. A portable secondary battery is used to supply them with current. The illumination of the hinged screen inside the box varies approximately as the cosine of the angle of incidence of the light from the electric lamps upon it. A handle with a pointer moving over a graduated scale is connected to the screen with a system of levers, and the inclination is so adjusted that the illumination of the screen is equal to that of the perforated diaphragm, the perforations seeming to disappear when this balance is affected. The illumination can then be read off on the scale in units of the illumination due to one standard candle at one foot distance. The object of the levers is to give an open and convenient scale. The scale is graduated by experiment, and does not depend upon the cosine law. The colour difficulty, where arc light or daylight is to be measured, is reduced by the use of a yellow-tinted diaphragm and a blue-tinted screen, the tints being selected so that the readings are the same as the mean of a large number of measurements made with white screens. By means of a graduated quadrant and a gnomon the angle and the cosine of the angle of incidence of the light from a lamp may be measured, and rules are given for deducing the height of the lamp and the slant height, and hence the candle-power of the lamp.

3. *On Storage Batteries.* *By* H. A. Earle.

The author traced the history of storage batteries from the time when Gautherot, in 1801, obtained secondary currents from silver and platinum plates which had been used in a voltameter to decompose a saline solution. Ritter, in 1803, was the first to make a secondary battery, in which he employed plates of gold separated by cloth or paper, moistened with a saline solution; and though he employed various metals, including lead, the secondary currents he obtained were only of short duration, and the batteries of only scientific interest. It would naturally be presumed that he would have noticed increased effects when using lead, but we find that he used salt water and not an acid solution, and on this account chloride of lead was formed, which is scarcely soluble and is a bad conductor.

De la Rive in 1826 obtained secondary currents from platinum plates in a voltameter filled with water, and he closely approached the elements of our present storage cells when, among his many experiments, he used in a primary battery a platinum plate covered with a film of peroxide of lead, and a zinc plate immersed in an acid solution.

The first powerful storage battery was introduced by Planté in 1860, but the method employed for its formation was too long and costly for practical purposes. Faure, in 1881, reduced this long process of formation by applying lead oxide in the form of a paste to the surfaces of the plates, but the adhesion was insufficient, and the life of the cells was too short to give them commercial value. Swan realised that the active material required a better mechanical support, and introduced a plate of grid form, the interstices serving to retain the material; and this frame, combined with the Faure pasting, was the origin of the plates largely used in this country and elsewhere.

The monopoly that existed for the manufacture of this plate caused other makers to turn their thoughts to the plain lead plates, and such great advances have been made both in their manufacture and method of formation, that it is rapidly replacing the pasted form.

A type that differs greatly from the solid lead plate, but which is not pasted, is the chloride plate, in which the material to become active is a mixture of chloride of lead and chloride of zinc cast into small tablets, which are framed by casting antimonious lead around them under high pressure. The subsequent elimination of the chloride and zinc leaves a porous structure of pure lead of a crystalline nature, of good conductivity, and with a large surface exposed to the electrolyte, the result being a large capacity for a given weight, and for the space occupied.

Omitting the question of cost, the chief points to be considered in connection with accumulators are—the chemical action, the mechanical construction, and the proper treatment of the cells when made.

The theoretical value of lead peroxide is 4·44 grammes per ampere hour, or, roughly, one pound is the equivalent of 100 ampere hours. Presuming that the positive and negative plates were identical, the value would be approximately 50 ampere hours for one pound of peroxide and spongy lead. As a matter of fact, the highest capacity plates yield only about seven ampere hours per pound of positive and negative plates, or sixteen ampere hours per pound of peroxide and spongy lead, due to the facts that a conducting frame of considerable weight has to be employed, and to the impossibility in practical working of reducing the whole of the peroxide. To obtain the best results for a given weight the frame must be reduced to a minimum consistent with the necessary strength and conductivity, and the distribution of the peroxide must be such as to admit of the perfect circulation of the electrolyte, and its penetration throughout the mass.

The behaviour of cells under various conditions is most interesting, and from the curves that can be plotted we can readily study the effects due to different rates of charge and discharge, to the penetration and strength of the electrolyte, and to the ratio of the weights of the positive and negative plates.

There is a given rate of charge which is most suitable to each type of cell, mainly due to the disposition of the active material, to its thickness, and to the method of its production, namely, whether it has been mechanically applied or electrolytically produced. Most of the effects of varying rates of charge can be ascertained from the resultant discharges, but discharge curves have nevertheless characteristics of their own, which are to a great extent unconnected with the conditions of charges.

A series of curves was exhibited to the Section which gave the capacities of seven types of plates at present in use; the yield was given in ampere hours per pound of positive and negative plates, the weight of one positive and one negative being taken in each instance; the variation in capacity for high and low rates of discharge was also shown.

The striking point in these curves is the great variation existing in the various types of plates now in use, but this can be explained to a great extent, for the heavy solid plates, the active material of which is formed out of the plates themselves, must have a large reserve of weight to give them life, while pasted plates, or plates with a large area, fall higher on the curve. One plate greatly exceeds all the others in capacity, and this is due to the nature of the active material, which permits the penetration of the electrolyte throughout the mass.

Regarding the voltage of a discharging cell, this varies greatly, and is dependent upon the rate of discharge, the strength of the electrolyte, and other causes. In considering this question, it will not be out of place to draw attention to conditions frequently met with in specifications for storage batteries.

In some instances a given percentage in fall of voltage is allowed; in others the voltage per cell is fixed to a hundredth of a volt, above which limit it must give the specified capacity. This type of specification is, as a rule, most unsatisfactory, for at what point does our initial voltage start? On open circuit? Immediately on closing the circuit, or five minutes afterwards? Further, may the cells stand for half a day after charging before the discharge is taken? The best way to meet this latter case is to take the first reading of voltage after the cell has commenced discharging, and when 3 per cent. of the specified discharge period has elapsed.

The most satisfactory specification to all concerned is for the amperes to be specified, and the time for which the discharge is to be maintained, the voltage of the complete battery at the end of the discharge being also given, the number of cells being omitted; this would require for a low voltage discharge per cell an increased number of cells, but a decreased number of plates, or *vice versâ*; and the author finds that this would not admit of the individual cells being worked to too low a voltage, and that the purchaser would obtain exactly what he requires at the lowest price.

When tests are made to check the efficiency and capacity of a battery, we can place no reliance on the figures obtained from a single charge and discharge; as a rule no two consecutive discharges are identical, even when discharged with the same current and down to the same voltage. In tables given in the paper the first ten charges and discharges from a new cell are recorded. These give a good idea of the very various nature of results obtainable with slight differences of charge. The figures show that the higher the voltage to which the cell is raised on charge, the lower the efficiency, and also that a change of condition of charge may increase or decrease the efficiency and output to an extraordinary extent.

The strength of the acid solution used has a great effect upon the behaviour of a cell, also upon its life and voltage; moreover, a weak solution has a high resistance, which diminishes as acid is added, till a specific gravity of about 1·250 is reached, when any addition of acid rapidly increases the resistance; the resistance also rapidly increases as the temperature falls. Each type of cell works best with a given strength of acid, but there are other most important points to be considered, namely, that different strengths of the electrolyte have great effect both on the capacity of the cell and upon its voltage.

Acid solutions of specific gravity from 1·1 to 1·3 will vary the voltage as much as 10 per cent., and the highest capacities for various types of plates are obtained with acid from specific gravity 1·2 to 1·3, and beyond these limits only a small percentage of the maximum capacity can be obtained, and the curves of mean voltage for different strengths of acid bear a most interesting relation to the various curves of capacity under the same conditions.

The action upon plates when first erected and immersed in the electrolyte can, to a great extent, be investigated by the fall and rise of its specific gravity, various results being obtained from plates in different states, and according to whether they are left standing or immediately charged. The conclusions drawn from many tests of this nature is, that fully formed positives with clean negatives are but little affected by standing, while partially formed positives and oxidised negatives sulphate rapidly.

Regarding the treatment of cells and their life the chief causes of destruction are impure acid solution, too prolonged or excessive rates of discharge, insufficient charging, overcharging, long periods of rest on open circuit without charging, and allowing cells to remain after complete discharge for many hours before recharging.

We find, therefore, that many causes influence the working and life of storage batteries, and that many of these can be varied at will; the problem, therefore, is to so combine all useful effects, that the best possible article is produced with due consideration to cost.

In a secondary battery we have lead, sulphuric acid solution, and the resultant compounds, and nothing else. The ideal cell is one that is indestructible, and this being given, the first cost and weight, if kept within reasonable limits, are of little moment.

At the present moment the life of a cell is its value, and its death is brought about by the disintegration of the active material. Now this disintegration is what we have to stop, the material is as good as ever, for nothing is wasted, and provided it were held in perpetual, firm, and good electrical contact with the frame in such a manner that the free circulation and penetration of the acid were not hindered, and the internal resistance not unduly increased, we should have produced an ideal and indestructible cell.

The author has discussed only a few of the many interesting features in connection with secondary batteries, being results obtained in practice.

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4. *The Development of the Telephone Service in Agricultural Districts.* *By* Major-General WEBBER, *C.B., R.E., M.Inst.C.E.*

On April 20, 1895, the 'Times' published a letter from the author on the subject in which public attention was drawn to the probability that the telephone, as well as light railways, might be beneficial to rural districts.

On May 14, 1895, in examination before the parliamentary committee which inquired into the development of the telephone service in the United Kingdom, the author also gave evidence on this subject.

He brings the subject before this Section in hopes that it may elicit discussion by practical telephone engineers. It need hardly be said that his selection of the county of Suffolk as an example of what can be done is especially appropriate to this meeting of the Association.

The map shown to illustrate the paper was the Ordnance survey, on a scale of 1 inch to 1 mile. Every town, village, or hamlet where a post office is situated is marked with a blue disc, and at each of these a telephone call-office would be established. When this is also a telegraph office a red flag is added, and at the twenty-nine towns where it is proposed that telephone exchanges should be established the blue disc is surrounded by a ring in red.

The total number of call-offices is 29.

The lines of railway on which there are postal telegraph wires are shown in red, those on the roads in blue, and the proposed extensions for telephones to the proposed call-offices in green.

Probable connections to private subscribers are not shown. These will be, in most cases, by means of twin wires on the same poles. In the case of all the 351 call-offices the communication will be by single conductors and earth-returns, the connections between the exchanges themselves being by twin wires.

It is thought probable that, whether the Post Office erects such a system in the country or not, there will be no difficulty in using the spare space on the existing Post Office poles, for which, if the work is *not* undertaken by the Post Office, a way leave to that department would be earned for the public revenue.

In most cases the railways have been avoided owing to the excessive charges for way leave and maintenance.

It is not proposed that these lines should be constructed with so costly material as that used by the Post Office.

If carried out by the County Council the whole of the work could be tendered for, and the poles supplied locally, and very little special labour would be required.

The poles, insulators, brackets, and wire will be of the same size as is used everywhere for light, permanent, military telegraph lines, and quite as efficient and lasting as the heavier material. The conditions are: 25 poles to the mile; small single shed porcelain insulators; screw brackets having a bent shank; the conductors to be of No. 16 bronze, and to be stretched within 9 inches vertically of one another.

The exchange offices will be placed either in county buildings or in private houses; the call-offices in private houses, where a small payment of 9*l.* per annum, with a percentage on the receipts above an average of 2*s.* a day gross, will suffice for rent, and for attendance, which could be given by a child over ten or twelve.

A revenue from the subscriptions of private subscribers may be anticipated, the subscriptions to vary between 6*l.* and 10*l.* a year, according to circumstances, situation, and services given.

The official use of the system by the county authorities is a value which the chief constables, surveyors, and clerks to the councils could probably estimate better than the author can.

The being able to converse with salesmen, markets, other farms, outlying bailiffs, and workmen is an assistance to agriculture which is apparently obvious.

Small tradesmen will be able by it to keep trade in local hands.

Regulations of transport and carriage of all kinds will be assisted.

Economies will be effected in distribution of perishable agricultural produce of all kinds.

Farm labour, male and female, would have improved means of obtaining information as to demand and supply.

The proposed charge for a 'talk' would be 2*d.* within one exchange area. 3*d.* beyond and inside the county.

How far this would affect the Post Office revenue in its various branches—telegraph, postal, and parcels—it is not easy to estimate. The author believes that compensation for losses in one direction will always be found in another.

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5. *Some Lessons in Telephony. By* A. R. BENNETT, *M.Inst.E.E.*

It has recently been demonstrated that the development of telephonic communication in the United Kingdom is inferior to that which has been attained in many foreign countries.

Why this is so may best be discovered by ascertaining by what means, technical or economical, those nations which have most conspicuously outstripped us have acquired their superiority. For the purposes of this paper the countries of Europe have been divided into three groups: (1) well telephoned; (2) indifferently telephoned; (3) badly telephoned.

A country may most properly be said to be well telephoned when its smaller towns and villages enjoy facilities; for the existence of a few large exchanges in the capital and chief towns does not entitle it to that distinction. France, Russia and Portugal all possess good exchanges in their capitals, but are nevertheless badly telephoned, since their smaller towns and villages are excluded from participating in the service. On the other hand we find that Norway, Sweden, Switzerland, Luxemburg, Denmark and Finland are in the first rank as well-telephoned countries, since not only their capitals and chief towns, but their villages and even hamlets, are provided with communication. With them the telephone is no longer a luxury, but an adjunct of everyday life, within reach of even the poorest.

Of these six countries, which compose Group I., four owe their development to companies and co-operative societies, and two—Switzerland and Luxemburg—to their Governments.

A considerable gap exists between the worst country of Group I. and the best of Group II. This is the German Empire, exclusive of Bavaria and Würtemberg, which possess their own systems independently. Thereafter the countries follow in the order indicated in the Table, which shows that Norway is the best and Russia the worst telephoned country of Europe.

The questions naturally arise, 'To what causes are such vast differences in development to be ascribed?' and 'Why is the United Kingdom, with its preponderating commercial importance and unparalleled spirit of enterprise, only tenth on the list, instead of first?'

A study of the table supplies the answer. It shows that telephonic development is proportional to the prevalence of the following features:—

(1) Low rates; (2) Local management of exchanges; (3) Facilities for rural intercourse; (4) Competition.

At least three of these are characteristic of each of the six countries which compose Group I.

On the other hand, they are almost completely absent from Groups II. and III., the leading characteristics of which are:—

(1) High rates; (2) Centralised management; (3) Neglect of small towns and rural districts; (4) Absence of competition.

On inquiring in what manner circumstances differ so greatly in the United Kingdom as to preclude the possibility of small towns and rural communities sharing in telephonic communication, it appears that the inelasticity of the prevalent system of tariffs, which was originally invented for towns, is chiefly to blame. In towns distances are short, and subscribers, if the switch-rooms are properly distributed, have seldom to pay more than the unit charge; but in country districts distances of several miles must often intervene between the subscriber and switch-room, and as the annual rental exacted increases rapidly with the distance, the charges become piled up by the extra mileage entirely beyond the means of the vast majority of the people. What is wanted is the application of the Austrian (which, with some modifications, has also been adopted in Luxemburg) system of tariffs, and under which all subscribers, whatever their distance

Order of Merit	Country	Population	Number of Exchange Telephones	Number of Persons to each Exchange Telephone	Characteristics of Management
			Group I.		
1	Norway .	2,000,917	13,943	144	Very low rates; local management of exchanges; good rural intercourse; no competition.
2	Sweden .	4,784,981	32,602	147	Very low rates; local management of exchanges; good rural intercourse; competition.
3	Luxemburg .	211,088	1,315	160	Very low rates; central management, but with delegated control, in some cases, to local authorities; good rural intercourse; no competition.
4	Switzerland.	3,000,000	17,422	172	Very low rates; central management, but with delegated control, in some cases, to local authorities; good rural intercourse; no competition.
5	Denmark .	2,185,335	10,325	211	Very low rates; local management of exchanges; good rural intercourse; no competition.
6	Finland .	2,412,135	7,351	328	Very low rates; local management of exchanges; good rural intercourse; competition.
			Group II.		
7	Imperial German Post Office territory	41,796,966	93,131	449	Fair rates for urban subscribers in large towns; high rates in small towns; highly centralised management; bad rural intercourse; no competition.
8	Bavaria .	5,594,982	12,400	451	Ditto.
9	Würtemberg	2,036,522	4,430	459	Low rates for urban subscribers, but with regulations tending to restrict suburban and rural intercourse; central management; no competition.
10	United Kingdom	37,880,764	*58,367 †1,202 59,569	636	High rates, with regulations unfavourable to development outside towns; partly local management; practically no competition.
11	Holland .	4,669,576	7,263	643	High rates in three chief towns, low rates elsewhere; management chiefly centralised; bad rural intercourse; no competition.
12	Belgium .	6,136,444	8,757	700	High rates in large towns, low rates of recent origin in small towns; central management; no competition.
			Group III.		
13	France . .	38,343,192	26,772	1,432	High rates; subscribers pay also capital cost of their installations except in Paris and Lyons; central management; bad rural intercourse; no competition.
14	Spain . .	17,800,000	10,984	1,618	High rates in large towns, recently introduced reduced tariff for small towns; local management chiefly; bad rural intercourse; no competition.
15	Austria .	23,895,413	14,574	1,640	Fair rates, but subscribers pay capital cost of their installations; central management; bad rural intercourse; no competition.
16	Italy . .	30,535,848	12,067	2,530	High rates in large towns, except in Rome, where competition exists; low rates in small towns; local management, but under strict Government supervision; bad rural intercourse; no competition, except in Rome.
17	Hungary .	17,463,473	5,563	3,139	High rates in towns; very low rates for village intercourse, but combined with regulations which tend to restrict communication between the towns, suburbs and villages; partly local management; no competition.
18	Portugal .	5,000,000	1,483	3,371	Exchanges in Lisbon and Oporto only; fair rates; no rural intercourse; no competition.
19	Russia . .	97,151,789	7,415	13,102	Highest rates in Europe in chief towns; high rates in small towns; partly local management, under Government rules; bad rural intercourse; no competition.

* Company. † Post Office.

may be from the switch-room, are put on an equality as regards annual subscription, the only difference being in the first payment made, which varies with the length of line required, the object being to reimburse the owners of the exchange system once for all for the additional cost of the extra mileage. In Austria the annual subscription is the same for any distance up to 15 kilometres ($9\frac{1}{4}$ miles), the difference being paid by the subscriber on joining the exchange. In Luxemburg the same system prevails, provided a subscriber is located not more than $1\frac{1}{2}$ kilometres from an existing route. The annual subscription is only 3*l.* 4*s.*, including all charges, and the right to communicate at will over the whole of the Grand Duchy, which measures about 44 × 30 miles. Compensation for increased distance is made in the form of a first payment (which may, if desired, be spread over five years) at the rate of 4*l.* per kilometre of the line which intervenes between the free radius which surrounds every switch-room and the subscriber's place. The effect of this tariff has been to cover the Grand Duchy with telephone lines. At the end of 1894 there were 59 switch-rooms (all in communication with each other by trunk lines) and 1,315 exchange lines. Dorsetshire has exactly the area (998 square miles) of Luxemburg, and practically the same population (211,000), yet it contains only three exchanges—Weymouth, Dorchester, and Poole—and about 70 subscribers. In Luxemburg there is an exchange telephone to every 160 inhabitants; in Dorsetshire one to 2,779. And many counties are worse off than Dorset. Such is the consequence of the different modes of management.

It cannot be said that such rates as are applied in Luxemburg do not pay. Accounts and balance-sheets have recently been published [1] which prove that even lower charges are made remunerative by local companies and municipalities in Holland, Denmark, and Norway.

The islands of Jersey and Guernsey are instanced as localities in which telephonic communication would be of great value could it be had on the Luxemburg plan. At present they are entirely deprived of its benefits owing to the inadaptability of the British system of tariffs to their local requirements—that is, to the needs of a scattered community. Particulars are furnished also of the Drammens Upland Telephone Company, which supplies a large and thinly populated district of Norway with an extensive telephonic exchange system at very low, but still remunerative, rates. As a contrast to the Channel Islands, the Aland Islands in the Baltic, belonging to the Grand Duchy of Finland, where there is an exchange telephone to every thirteen inhabitants, are mentioned.

The technical features of the Continental systems are, as a rule, best where the tariffs are lowest and the extension of communication greatest. The conditions laid down by the author in his paper on 'The Telephoning of Great Cities,' read at the Cardiff meeting of the Association in 1891, as being necessary to a well-ordered exchange, are fulfilled more nearly in Sweden than elsewhere, especially by the General Telephone Company of Stockholm. Metallic circuits are universal; special attention is given to prompt switching, and Stockholm is divided into eight nearly equal divisions, each containing a switch-room, whereby the prompt and economical addition of new subscribers is rendered easy. The speed attained in switching is that stated in the paper to be practicable and proper in a good exchange, viz., 10 seconds when two switch-rooms are brought into requisition, and 5 seconds when only one is required to complete a connection. The countries of Groups II. and III. are, with some exceptions, technically behind those of Group I.

[1] *The Telephone Systems of the Continent of Europe.* By A. R. Bennett. London, Longmans, Green & Co.

TUESDAY, SEPTEMBER 17.

The following Papers were read:—

1. *The Field Telegraph in the Chitral Campaign.* *By* P. V. Luke, *Deputy Director-General of Indian Telegraphs.*

The field telegraph required for the army in India, for the many small expeditions in which it is so often engaged, is furnished by the Civil Telegraph Department. The department must be ready therefore at all times to meet any demands made upon it. A suitable equipment has been designed, and a stock is kept at convenient depôts at various points on the frontier; this enables an immediate start to be made with the construction of the field telegraph in any operations, while for prolonged operations the whole resource of the Civil Telegraph Department can be made available.

All the equipment is arranged for 'pack' carriage; the maximum weight of any one package is fixed at 80 lbs. (one half the load a mule will carry). After every campaign a full report is sent in of the working, and any defects brought to light are dealt with at once.

The receiving instrument used is a sounder similar to the one used throughout India, only reduced in size. It is fitted on a base-board with a small Siemens relay and a key, with connections so arranged that it can either be worked 'direct' or as a 'local.' A perfect portable battery has still to be designed; at present the so-called 'dry' pattern is used.

The unit of office equipment, or total needed for one field office, which includes tents, &c., comprises seven mule loads, but it can be compressed to four loads if necessary for an emergency and for temporary work. Telephone apparatus is always included. The line wire employed is iron wire weighing 300 and 150 lbs. per mile, and stranded hard copper wire weighing 80 lbs. per mile; light field cable is used for certain purposes. For poles, where possible, the resources of the country passed through are utilised; but for bare country, iron poles are carried. They are tubular sheet iron in three pieces, fitting telescopically; the total height is 18 feet, and weight 40 lbs., the packages being 5 feet long. At twenty to the mile they will carry three wires, one in a cap, the other two on insulators.

The rate of construction depends on the transport, labour, and character of country. In the Waziristan campaign a single wire line was put up at rate of nine miles a day for five consecutive days.

Special arrangements for rapid repair are always made; for this purpose it is necessary to have a telegraph office at every ten miles, with a trained line staff. For the signalling staff, trained British soldiers are mainly used; these men are employed at other times at different telegraph offices throughout the country, usually where their regiments are quartered.

The Field Telegraph forms a distinct department in the field, under a civilian telegraph officer appointed by the Director-General of Telegraphs, and taking his orders from the chief of the staff.

Information of the siege of Chitral came from Gilgit over the line which was only completed in 1894. This line is carried over two passes, one 11,600 feet, the other 13,500 feet above sea level, where the snow lies from 10 to 18 feet, yet it worked well all through the winter. The staff at the observation stations close to these passes are entirely cut off from the rest of the world except by wire for seven months in the year. The place selected as the base of operations was Holi Mardan; best material for a two-wire 200-mile line with twenty offices was at once collected, together with the necessary staff for constructing and working. From this point the wire was pushed on as fast as possible, and a field office was opened on the Malakand Pass a few hours after the battle. At first it was a single-wire line, but it was afterwards made a three-wire line as far as the Swat Valley, then a two-wire to Dir, and finally one-wire to Chitral Fort.

Great difficulties with transport occurred at Lowari Pass, owing to the pass not being passable for camels; but for this the wire would have been into Chitral by May 12—as it was it did not reach there till midnight of the 17th.

On account of the scarcity of timber it was necessary to use iron poles very extensively; at the Lowari Pass, however, there is a fine pine forest; wooden poles were afterwards used.

After May, cutting the wood became very frequent, and even very difficult to stop.

After the start the traffic, which was exceedingly heavy, was dealt with, with but little delay; in April 24,370 and in May 58,935 messages were dealt with, and their length was much above the average. Shortly after the Malakand fight, by clearing the line right through to Simla, the Commander-in-Chief was enabled to talk direct to General Low, and in spite of heavy rains at the time the communication was excellent.

To give some notion of what was accomplished, it may be stated that a telegram dated Chitral Fort, May 19, was published in the London papers of the same date.

The Telegraph Department also assists in defending camps by running wires round the camp, so arranged that an alarm is at once given by the ringing of a bell in the Quarter Guard should a night surprise be attempted, and in many other ways much aids and assists the military authorities.

Medals and decorations are given to the staff at the conclusion of the campaign.

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2. *A Movement Designed to attain Astronomical Accuracy in the Motion of Siderostats. By* G. JOHNSTONE STONEY, *F.R.S.*

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3. *On Modern Flour Milling Machinery. By* F. W. TURNER.

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4. *On the Production of Letterpress Printing Surfaces without the use of Types. By* JOHN SOUTHWARD.

The author describes a recent invention, known as the 'Linotype' Composing Machine, which enables certain kinds of letterpress printing—namely, the plain text of books and newspapers—to be done without the use of types. The invention constitutes a remarkable improvement upon the present methods of typography, which, in all essential particulars, have remained unchanged during the last four and a half centuries.

Hitherto, letterpress printing surfaces of the kind referred to, or those representing alphabetical characters, have been formed by combining together, or 'composing'—to use the technical term—movable interchangeable types, having cast upon them in *relief* the characters they are to represent. In the Linotype system, instead of such types being composed, *matrices*, corresponding to them to the extent of having characters engraved upon them, but in *intaglio*, are set up. When a sufficient number of matrices to form a line of given length are assembled, they are cast from, and a bar of metal formed, which has a surface in relief, precisely equivalent, for printing purposes, to one consisting of separate types. A large number of newspapers in this country, and especially in the United States, have within the last year or two adopted this system, and entirely dispensed with types for the whole of their contents, with the exception of what are called 'displayed' or ornamental advertisements. Many books have lately been printed in the same manner.

The Linotype machine comprises mechanism for—first, composing the matrices; second, casting from them when they complete a line of reading matter; third, distributing them back again to their proper magazines in order that they may again and again be used to form succeeding lines. These three operations are carried on concurrently; that is to say, while the matrices for one line are being composed, those of the previous line are being cast from, and at the same time the matrices for the line before that again are being distributed. The result is that lines of, as it were, stereotyped matter are produced much more rapidly than the most expert compositor could put together the types or letters of which they consist.

The matrices are stored in the upper part of the machine in an inclined magazine with compartments in which the matrices are assorted in a somewhat similar manner to that in which the types are contained in the boxes of an ordinary 'compositor's case.' The matrices tend to slide downward by gravity out of this magazine.

In the lower part of the machine there is a keyboard and connected mechanism, whereby, each time a key is depressed by the finger of the operator, a single matrix, bearing the character corresponding to the key, is permitted to fall out of the mouth of the magazine through vertical channels. The matrix then comes in contact with an inclined travelling belt, which carries it and succeeding matrices downward, one after another, into the 'assembling block,' where they are composed, or set up side by side in a row.

After the line is thus composed it is transferred to the casting mechanism, by which the metal is injected into the incised lines or letters of the matrices. The casting box or mould provides for a bar being cast similar in height and body to a line of types. It is finished by knives, which shave off the feet and trim or plane the sides. One after another the line bars are sent into a receiver or galley, where they are made up like lines of type matter; but, of course, with much greater facility than types, being all in one piece.

Before referring to the third operation, distributing, it is necessary to describe the *matrix*. This is a piece of brass $1\frac{1}{3}$ inch long, by $\frac{3}{4}$ inch wide. Its thickness is that of the letter or point to which it corresponds. The character it is to produce is punched on to the side, where there is a cavity, in which the letter is engraved in *intaglio*, so that the casting made from it will be in *cameo*—that is, in relief. At the upper end of each matrix are teeth, arranged in a peculiar order or number, according to the character. That is, a matrix bearing any particular letter differs as to the arrangement of its teeth from a matrix of any other letter.

These teeth are relied on as the means for effecting the distribution or re-assembling of the matrices. Above the open upper ends of the magazine channels is fixed a bar which has longitudinal ribs on its lower edge. These ribs are adapted to engage the teeth of the matrices, and to hold them in suspension. The ribs of the distributing bar vary in conformation at different points in its length, there being a special arrangement over the mouth of each channel of the magazine.

The matrices to be distributed are simply pushed forward horizontally upon the bar, so as to hang from it. Each matrix is thus suspended until it arrives over its proper channel, and on reaching this point the arrangement of the bar and the teeth permit the matrix to become disengaged, when it falls directly into the channel. Other matrices are meanwhile continuing their course along the bar to their proper points of disengagement. Thus the distribution is done entirely mechanically and automatically.

One of the advantages of thus using matrices instead of type can, perhaps, only be fully appreciated by those who are practically acquainted with the operation of type-setting. The lines of a column or a page must all, except those which begin and end paragraphs, be of a uniform length—not of irregular lengths like the lines of a page of type-writing. When the compositor finds that a line is short, and he cannot break a word because the recognised rules bearing on the division of words do not permit it, he has to insert extra or additional space between the words, in order to spread out the matter to the prescribed length. It is impossible beforehand to calculate the space that will be occupied in any line by a certain number of words, because the letters of which they are formed vary so much in width. Spacing out the matter to form a full line is called justifying, and the necessity for doing it greatly retards the hand compositor. In the Linotype machine 'space bars' are used, which consist of two steel wedges, which slide upon each other, the planes of the outer edges being always parallel. These are inserted between the matrices of each word as set up, and when pushed up spread out the words, making the line of the required measure.

The Linotype machine produces letterpress printing surfaces much more expeditiously and economically than they can be produced by hand composition, or even by type-setting machines. Ordinary operators attain a speed of 8,000 to 10,000 letters per hour, whereas the hand compositor averages about 1,500 per hour. This increased product is attributable, first, to the greater speed at which matrices, as compared with types, can be operated on; and, secondly, to the possibility of performing automatically in one machine the two subsidiary operations of justifying and distributing which together amount to at least 33 per cent. of the work of the compositor. The machine also effects a great saving upon the cost of a printing office, as type, cases, and other appurtenances are unnecessary.

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5. *Memorandum on the British Association Screw Gauge for small Screws. By* R. E. Crompton, *M.Inst.C.E., Pres.Inst.E.E.*

As a result of the two reports presented by the committee appointed by the British Association to design a standard screw gauge for small screws, a large number of users, including H.M. Post Office, have adopted them. In 1890 the London Chamber of Commerce appointed a committee to forward the question of making the British Association screw gauge universal among electrical manufacturers, and a circular was sent round to the entire electrical manufacturing trade, with the result that with hardly any exceptions the whole trade promised to adopt the screws, and thus ensure the extremely desirable result of making all the small screws used in electrical apparatus interchangeable. It is, however, much to be regretted that a considerable number of users of small screws (the principal offenders having their works in Birmingham) are still using other gauges, and thus complete uniformity has not been obtained up to the present time. One great difficulty in this matter has been that of obtaining standard gauges which could be referred to in specifications or orders for such screws. Wherever it is desired that the screws should be thoroughly interchangeable it is necessary in such specifications to have a paragraph somewhat as follows:—

'Testing. Each box of screws will be tested as follows: A handful of one dozen screws will be selected at random from each box; these will be tested both as to the screw portion and the plain portion of the shank by being respectively screwed or pressed through the corresponding maximum and minimum gauge holes in the standard plates supplied on loan with the order, and which must be returned with the finished screws. Any screw which cannot be screwed or pressed by hand into the maximum female gauge, or which can be screwed or pressed by hand without forcing into the minimum gauge, will be rejected. If more than one screw in each dozen thus tested is so rejected the whole box will be returned to the contractors.'

Four years ago I found it necessary to have standard plates made for the purpose of ordering screws to the above specification. I had a number of such plates prepared, but found the very greatest difficulty in getting them made so that they would fulfil their required duty, the makers giving as an excuse that there was no standard B.A. gauge then existing to which they could refer. This difficulty can only be removed by a complete set of standards being made and deposited either with the Board of Trade or at the Society of Arts, or with a similar central institution; and it is highly desirable that the British Association should either call together the surviving members of the original committee or form a new committee to consider the question of making up these standard gauges and deciding on the place where they are to be deposited.

One question for the committee would be the requisite allowance of clearance between the absolute diameters of the various sizes as laid down in the report of the committee and the sizes of the maximum and minimum gauge holes in the gauge plates.

Another point of importance in order to make this standard screw gauge universal would be the issue of a short descriptive report, with illustrations, giving the sizes, clearances in gauge plates, best method of reproduction on English lathes of these screws, together with a few sectional drawings showing the shape of thread, rounding off, &c.

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6. *A Uniform Factor of Safety for Boilers and Machinery of Steamships* *By* JOHN KEY.

The subject of this paper has arisen out of the fact that no uniform code of international regulations has yet been adopted by the various maritime countries and States for the general safety of machinery on board steamships, especially regarding the construction and strength of marine boilers and their connections.

A uniform factor or margin of safety might be devised on broad and intelligible grounds, without making any violent change, on the basis, not of the breaking strength, but of the elastic limit of the material—ascertained carefully by a uniform method of conducting tests—that would be accepted by all civilised countries, in order that any steamship passed at one port for a properly certified working pressure might not, when new, be altered or reduced at another, similar in principle to the British system of measurements for ascertaining gross tonnage, and the regulations for preventing collisions at sea.

The following tabulated statement shows at a glance the working pressures for cylindrical shells of steel boilers allowed by the rules of the various authorities:—

Steel shells	Percentage of Joint	Admiralty	Board of Trade	Lloyd's	British Corporation	Hamburg	Bureau Veritas
diam. thickness ft. in.		lbs. per sq in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.	lbs. per sq. in.
5 0 × ⅜ in.	70	133·8	116·06	86·3	102·08	109·4	113·3
5 0 × ½ in.	70	178·4	154·7	129·4	142·9	146·3	152·8
12 0 × ¾ in.	80	127·47	117·7	111·1	114·6	111·2	112·4
12 0 × 1 in.	80	169·96	157·0	155·5	156·2	148·3	152·0
12 0 × 1¼ in.	80	212·45	196·2	200·0	197·9	185·4	191·6
16 0 × 1½ in.	82	196·0	181·04	187·9	184·2	170·9	177·7

The water-pressure test allowed by the British Admiralty shall not exceed four-ninths of the ultimate strength of the shell, and the working pressure is fixed at 90 lbs. below the test-pressure, which is called their 'constant margin' of safety for all pressures.

The Board of Trade allow a factor of safety 4·5, with additions according to the circumstances of each case.

Lloyd's Committee add ⅛ inch, and the

British Corporation add $\frac{1}{16}$ inch to all thicknesses for wear, and their constants vary according to the form of riveted joint.

Hamburg rules allow a factor of safety 5·0, reduced to 4·7 when the longitudinal seams are drilled and double riveted.

Bureau Veritas allow a factor of safety of 4·4 after the plates have been corroded away by 0·04 of an inch.

These authorities all differ in their respective rules for diameter of shafts, thickness of plates forming flat surfaces, stress on stays, thickness of plain or corrugated furnace tubes, steam-pipes, and area of safety valves.

As an example of how unnecessarily we are hampered by want of uniformity even in boiler fittings and connections in the case of water-gauges, the English Board of Trade insist on having cocks or valves next the shell of the boiler, whereas the German Board of Trade will not have such a fitting; with the consequence that ships running to Hamburg are fitted with two standpipes, one with cocks and one without, to which our English Board of Trade has to shut its eyes, as the German standpipe, from their point of view, is unsafe and ought not to be allowed.

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7. *Experiments on the Transfer of Heat through Plates with Variously Arranged Surfaces. By* WILLIAM GEORGE WALKER, *M.Inst.M.E., A.M.Inst.C.E.*

The object of these experiments is to compare the effects on the transfer of heat of variously arranged surfaces projecting from the primary surface of a plate in contact with steam, air or water.

Two cylindrical smooth vessels were constructed of exactly similar dimensions, cut from the same brass tube, $6\frac{3}{4}$ inches in length and $2\frac{1}{16}$ inches in diameter, fitted with water-tight lids, through which thermometers were inserted. When filled with water no difference was found to exist between their respective powers to absorb or discharge heat. One of the cylindrical vessels was then fitted with copper ribs $5\frac{1}{2}$ inches long, $\frac{3}{4}$ inch wide, ·012 inch thick, soldered on longitudinally. The ribs were spaced equally round the cylinder and tried as follows:—

1. Eight external ribs.
2. Sixteen ribs, eight external and eight internal.
3. Eight internal ribs.

The heating of the two cylinders was performed by suspending them in steam from boiling water. The two cylinders to be compared were filled with water, and placed in steam when their temperatures were 65° Fahr.

The reading of the thermometers, together with the time, was noted simultaneously at every 10 degrees. The time was taken in seconds by a ship's chronometer. When the thermometers became stationary at 210° Fahr. the cylinders were suspended either in air or water and allowed to cool down, the temperatures being noted every 10° Fahr. and the time in seconds.

The difference between the temperatures of the corresponding plain and ribbed cylinders increased from zero and reached a maximum, after a certain time after which they again closed to equal degrees.

The ribbed surfaces increased to a considerable extent the rapidity of transfer of heat either when absorbing heat from steam or discharging it into the air. The effect was not so great when cooled in water. In the externally ribbed cylinder the greatest advance in temperature over the corresponding plain one was 18° Fahr., 33° Fahr., 8° Fahr., when in contact with steam, air, and water respectively. The addition of the internal ribs to the external ones did not produce much effect. With the internal ribs alone, the rapidity of transfer of heat was increased when cooled in water, but practically no effect was perceived when in steam or air.

The external ribs were more effectual in discharging heat to the atmosphere than in absorbing it from steam. This difference may be due to the condensed layer of water which was deposited on the surface.

Coiling wire round was also tried. The temperature of the coiled cylinder fell faster than the corresponding plain one in air, but rose slower in steam—due probably to the condensed layer of water deposited between the wire coils. No difference was noticed when cooled in water. The comparison of rough and smooth surfaces when absorbing heat from steam or discharging it into air or water was also tried.

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8. *A New Principle of Aërial Navigation. By* Lieut. B. BADEN-POWELL.

It has been the constant desire of inventors to devise some means by which we may be able to navigate the atmosphere. Wings, vertical screws, aëroplanes, have all had their advocates, and great hopes were aroused in the balloon. Many proposals were made for steering this aërial buoy, and sails and rudders were applied to the apparatus, until scientists pointed out that these could be of no avail on any apparatus which floated in, and with, one medium. Yet it is this very principle which I wish to advocate, and to state broadly a method by which I believe we might sail through the air, which depends upon three well-established facts. First, a kite retained by a string will ascend when a wind is pressing on its under surface, and will raise a considerable weight. Secondly, in the absence of wind, the same effect may be produced by drawing along the kite through still air. I have myself been lifted by a large kite under such circumstances. Thirdly, by balloon ascents, observations on clouds, mountain records, and especially observations on high places as the Eiffel Tower, it has been found that the wind almost invariably increases in velocity the higher we get, so that the currents of air 1,000 feet up move about three times as fast as those below. It follows from these principles, that if two kites connected by a long string, so arranged that one floats in a current of air blowing at a different rate (or different direction) from that in which the other floats, there will be a reciprocal action, the kite in the lower medium being supported by being drawn along by the kite in the higher stratum, which in its turn is kept aloft by being retarded by the other.

A kite of 1,000 square feet area is capable of supporting a man in a breeze of 10 miles an hour, or when being towed at that rate through calm air. If the wind near the surface of the earth be blowing at this rate (rather below the average), it will usually be travelling at 30 miles per hour at an elevation of 1,000 feet.

With two such kites connected together by a long rope, with a car attached to the rope near the lower kite, if the lower one be drawn along 10 miles an hour faster than the wind, it will support a man, and travel at a rate of 20 miles an hour. But if the upper kite travel at this rate it will be retarded to an extent of 10 miles an hour, and hence the whole apparatus will float along with the wind. In this way we might make a light apparatus for navigating the air. The extent to which it might be steered out of the wind's course, practice alone can determine, but even if this be not much, we still should have an air-ship possessing very many advantages over a balloon, and to which propelling agents could be much more easily applied.

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9. *Receiver and Condenser Drop.* *By* Professor A. E. ELLIOTT.

SECTION H.—ANTHROPOLOGY.

PRESIDENT OF THE SECTION.—Professor W. M. FLINDERS PETRIE, D.C.L., L.L.D.

THURSDAY, SEPTEMBER 12.

The PRESIDENT delivered the following Address:—

IN a subject as yet so unmapped as anthropology there is more room for considering different points of view than in a thoroughly organised and limited science. The future structure of this science depends largely on the apprehension of the many different modes of treating it. The time has not yet come when it can be handled as a whole, and therefore at present we may frankly consider various questions from an individual standpoint, without in the least implying that other considerations should not be taken into account. It is only by the free statement, however onesided, of the various separate views of the many subjects involved in such a science, that any comprehensive scheme of its organisation can ever be built up. In remarking, therefore, on some branches at present I shall not attempt a judicial impersonality, but rather try to express some views which have not yet been brought into ordinary currency.

Elaborate definitions of anthropology have been formulated, but such are only too liable to require constant revision as fresh fields of research are added to the domain. In any new country it is far safer to define its limits than to describe all that it includes; and all that can yet be safely done in anthropology is to lay down the 'sphere of influence,' and having secured the boundaries, then develop the resources at leisure. The principal bordering subjects are zoology, metaphysics, economics, literature, and history. So far as these refer to other species, as well as to man, or to individuals rather than to the whole race, they stand apart as subjects; but their relation to the human species as such is essentially a part of anthropology. We must be prepared, therefore, to take anthropology more as the study of man in relation to various and often independent subjects, than as an organic and self-contained science. Human nature is greater than all formulæ; and we may as soon hope to compact its study into a logical structure, as to construct an algebraical equation for predicting its course of thought.

Two of the commonest and most delightfully elastic words in the subject may be looked at once more—'race' and 'civilisation.' The definition of the nature of race is the most requisite element for any clear ideas about man. Our present conception of the word has been modified recently more than may be supposed by our realising the antiquity of the species. When only a few thousand years had to be dealt with nothing seemed easier or more satisfactory than to map out races on the assumption that so many million people were descended from one ancestor and so many from another. Mixed races were glibly separated from pure races, and all humanity was partitioned off into well-defined divisions. But when the long ages of man's history and the incessant mixtures that have taken place during the brief end of it that is recorded come to be realised, the meaning of 'race' must be wholly revised. And this revision has not yet taken effect on the modes of thought, though it may have demanded the assent of the judgment. The only meaning that a 'race' can have is a group of persons whose type has become unified by their rate of assimilation and affection by their conditions exceeding the rate of change produced by foreign elements. If the rate of mixture exceeds that of assimilation, then the people are a mixed race, or a mere agglomeration, like the population of the United States. The greatest problems awaiting solution are the conditions and rate of assimilation of races—namely, what period and kind of life is needed for climatic and other causes to have effect on the constitution and structure, what are the causes of permanence of type, and what relative powers of absorption one race has over another. Until these problems are reduced to something that can be reasonably estimated we shall only grope in the dark as to all racial questions.

How, then, can these essential problems be attacked? Not by any study of the lower races, but rather by means of those whose history is best recorded. The great mode of isolation on which we can work is religious difference, and oppressed religious minorities are the finest anthropological material. The first question is—given a mixture of various races in approximately known proportions, isolated, and kept under uniform conditions, how soon does uniformity of type prevail? or what proportions of diversity will be found after a given number of generations? A perfect case of this awaits study in the Copts, who have by monogamy and the fanaticism of a hostile majority been rigorously isolated during 1,200 years from any appreciable admixture, and who before this settling time were compounded of eight or ten different races, whose nature and extent of combination can be tolerably appraised. A thorough study of the present people and their forefathers, whose tombs of every age provide abundant material for examination, promises to clear up one of the greatest questions—the effect of climate and conditions on assimilating mixed peoples. The other great problem is, How far can a type resist changes of conditions; provided it be not mixed in blood, so as to disturb its equilibrium of constitution? This is to be answered by the Jews and the Parsis. As with the Copts, an oppressed religious minority has no chance of mixture, as all mixed marriages are abhorrent to its exclusiveness, and are at once swept into the hostile majority. The study is, however, far more difficult owing to the absence of such good conditions of the preservation of material. But nothing could throw so much light on this as an excavation of some Jewish cemeteries of a thousand years or so ago in various European countries, and comparison of the skeletons with the proportions of the Jews now living. The countries least affected by the various proscriptions and emigrations of the race would be the proper ground for inquiry. When these studies have been made we shall begin to understand what the constants of a race really are.

We will now look at another word which is incessantly used—'civilisation.' Many definitions of this have been made, from that of the Turk drinking champagne, who remarked about it that 'after all, civilisation is very nice,' up to the most elaborate combinations of art and science. It is no doubt very comfortable to have a word which only implies a tendency, and to which everyone can assign his own value; but the day of reckoning comes, when it is brought into arguments as a term. Civilisation really means simply the art of living in a community, or the checks and counterchecks, the division of labour, and the conveniences that arise from common action when a group of men live in close relation to each other. This will perhaps be objected to as including all—or nearly all—mankind in its scope. Quite true; all civilisation is relative and not absolute.

We shall avoid much confusion if we distinguish high and low types of civilisation, and also perfect and imperfect civilisation. Like organisms we may have a low type of civilisation very perfect in its structure, capable of endless continuance, and of great shocks without much injury. Such are some of the civilisations of the African races who have great orderliness and cleanliness of arrangements, and are capable of active recuperation after warfare, without any internal elements of instability. Again, some low types are very imperfect, and can exist only by destruction of others, while any severe shock destroys their polity; the governments which only exist by raids and plunder, such as that of the Zulus, illustrate this. Turning to high types of civilisation we may see them perfect or imperfect. Countries of financial stability, not undergoing any rapid organic changes, are the more perfect in type; while those deeply in debt and in continual revolution have but imperfect civilisation, of however high a type it may be. With these distinctions before us,—that all civilisation is a question of degree,—that there are types of all variety, from the highest complexity to the lowest simplicity, and of all degrees of perfection, or stability and completion, in any given level of complexity—with these distinctions some of the vagueness of verbal usage may perhaps be avoided.

Turning now from words to things, we may perhaps see some ground for further consideration in even one of the best elaborated departments.

In the much-vexed question of skull measurements, the paucity of clearly defined racial characteristics may make us look more closely as to whether we are working on an analytic or an empirical method. In any physical problem the first consideration is the disentangling of variables, and isolation of each factor for separate study. In skulls, however, the main measures are the length, which is compounded of half a dozen elements of growth, and the breadth and height, each the resultant of at least three elements. Two skulls may differ altogether in their proportions and forms, and yet yield identical measures in length, breadth, and height. How can any but empirical results be evolved from such a system of measurement alone?

A departure from this mechanical method has appeared in Italy last year by Professor Sergi. He proposes to classify skulls by their forms,—ellipsoid, pentagonoid, rhomboid, ovoid, &c. This, at least, takes account of the obvious differences which the numerous measurements wholly ignore. And if skulls were crystals, divisible into homogeneous classes, such a system would work; only, like all organic objects, they vary by infinite gradation.

What then lies behind this variety of form? The variety of action in the separate elements of growth. Sergi's ellipsoid type means slight curvatures, with plenty of frontal growth. His pentagonoid means sharper curvatures. His rhomboid means sharp curvatures with small frontal growth. And so in each class, we have not to deal with a geometrical figure, but with varying curvatures of the centre of each plate of the skull, and varying extent of growth from the centres.

The organic definition of a skull must depend on the statement of the energy and direction of each of the separate elements out of which it is built. The protuberances or eminences are the first point to notice. They record in their curves the size of the head when it attained rigidity in the centres of growth. Every person bears the fixed outline of parts of his infant skull. Little, if any, modification is made in the sharpness of the curves between infancy and full growth; perhaps the only change is made in course of the thickening of the skull. Hence the minimum radius of curvature of each plate of the skull is a most radical measurement, as implying early or late final ossification. In higher races finely rounded skulls with slight curvatures are more often found; and this agrees with the deferred fixation of the skull pointed out by the greater frequency of visible sutures remaining, both effects being probably due to the need of accommodating a more continued growth of the brain. The length of growth of each plate from its centre in different directions regulates the entire form of the skull. The maximum breadth being far back implies that the parietals grow mostly toward the frontal or *vice versâ*. The top being ridged means that the parietals grow conical and not spherically curved, and hence meet at an angle.

It seems, therefore, that looking at the question as a physical problem, we are far more likely to detect racial peculiarities in the separate data of the period of fixation of the skull, and of the amount of growth in different directions, than by any treatment of gross quantities which are compounded out of a number of variables. The practical development of such a view is the work of the embryologist: here we only notice a principle of treatment of a most complex question, which seems to have too often been dealt with as if it were as simple as the definition of a crystal.

When we next turn to look at the works of man, it seems that the artistic side of anthropology has hardly been enough appreciated. In the first place, the theory of art has been grounded more assuredly by anthropological research than by all the speculations that have been spun. The ever-recurring question 'What is art?' whether in form or in literature, has been answered clearly and decidedly. When we contrast a row of uninteresting individualities with the ideal beauty and expression of a composite portrait compounded from these very elements, we are on the surest ground for knowing how such a beautiful result is obtained. In place of the photographic verity of the person we have the artistic expression of a character. Whatever is essential remains, and is strengthened; whatever is transient and unimportant has faded away. No one can look, for instance, at the composite heads of Jewish boys and their individual components, published some years ago in the 'Anthropological Journal,' without feeling the artistic beauty of the composite and the unbalanced characters of the individuals. What the camera does mechanically by mere superposition, the artist does intelligently by selection. The unimportant, unmeaning phases of the person, the vacuities of expression, the less worthy turns of the mind are eliminated, whether in form or in words, and the essence of the character is brought out and expressed. Such is the theory of artistic expression which anthropology has established on a sure basis of experiment, and which is thus proved to be neither fanciful nor arbitrary, but to be a truly scientific process.

And as anthropology has thus aided art, the converse is also true—art is one of the most important records of a race. Each group of mankind has its own style and favourite manner, more particularly in the decorative arts. A stray fragment of carving without date or locality can be surely fixed in its place if there is any sufficient knowledge of the art from which it springs. This study of the art of a people is one of the highest branches of anthropology and one of the most important, owing to its persistent connection with each race. No physical characteristics have been more persistent than the style of decoration. When we see on the Celtic work of the period of La Tène, or on Irish carvings, the same forms as on mediæval ironwork, and on the flamboyant architecture of France, we realise how innate is the love of style, and how similar expressions will blossom out again from the same people. Even later we see the hideous C-curves, which are neither foliage nor geometry, to be identical on late Celtic bronze, on Louis XV. carvings, and even descending by imitation into modern furniture. Such long descent of one style through great changes of history is not only characteristic of Celtic art, but is seen equally in Italy. The heavy, stiff, straight-haired, staring faces of the Constantine age are generally looked on as being a mere degradation of the imported Greek art; but they are really a native revival, returning to old Italian ideals, so soon as Greek influence waned. In the Vatican is an infant Hercules of thorough Constantinian type, yet bearing an Etruscan inscription, proving the early date of such work. Further east the long-persistent styles of Egypt, of Babylonia, of India, of China, which outlived all changes of government and history, show the same vitality of art. We must recognise, therefore, a principle of 'racial taste,' which belongs to each people as much as their language, which may be borrowed like language from one race by another, but which survives changes and long eclipses even more than language. Such a means of research deserves more systematic study than it has yet received.

But if we are to make any wide comparisons and generalisations a free study of material is essential, and the means of amassing and comparing work of every age is the first requisite. This first requisite is unhappily not to be found in England. The conception of collecting material for the study of man's history has as yet little root, and struggles to find a footing between the rival conceptions of the history of art and the life of modern man. The primary difficulty is the character of the museum accommodation at present provided. This is all of an elaborate and expensive nature, in palatial buildings and on highly valuable sites. To house the great mass of objects of either ancient or modern peoples in such a costly manner is impracticable, and hence at present nothing is preserved but what is beautiful, strange, or rare. In short, our only subjects of study are the exceptional and not the usual products of races. The evil traditions of a 'collection of curiosities' still brood over our materials; and until we face the fact that for study the common things are generally more important than the rare ones, anthropology must remain much as chemistry would if it were restricted to the study of pretty colours and sweet scents.

Until we have an anthropological storehouse on a great scale we cannot hope to preserve the materials which are now continually being lost to study for lack of reasonable accommodation. Such a storehouse should be on the cheapest ground near London, built in the simplest weather-tight fashion, and capable of indefinite expansion, without rearrangement or alteration of existing parts. It should contain no baits for burglars, all valuable objects being locked up in the security of the British Museum, to which such a storehouse would form a succursal, greatly relieving the present overcrowded state of many departments. To such a storehouse for students all that does not serve for public education, or that is not portable or of much saleable value, should be consigned. There the piles of architectural fragments which are essential for study, but are useless to show the public, should be all stacked in classified order. There the heaps of pottery of ancient and modern races should all be arranged to illustrate every variety of form and style. There the series of entire tombs of other races and of our own should be set out in their original arrangement, as in the Bologna Museum. There whole huts, boats, &c., could be placed in their proper order and sequence, while photographs of the showy educational specimens and valuables in the public museums could fill their places in the arrangement. That such a storehouse is needed may be illustrated by a collection gleaned in a few months' work this year. It represents the small products of a little village and a cemetery of a new race in Egypt. But there is no possibility of keeping such a collection together in any London museum; and but for the new Ashmolean Museum at Oxford having been lately built with a wide view to its increase, it is doubtful if in any place in England such a collection could be kept together. What happens to one excavator this year may happen to a dozen excavators *per annum* in a generation or two hence; and so long as space is not available to preserve such collections when they are obtained, invaluable material is being irrevocably wasted and destroyed.

Besides the theoretical and scientific side of anthropology there is also a very practical side to it which has not received any sufficient development as yet. Anthropology should in our nation be studied first and foremost as the art of dealing with other races. I cannot do better than quote a remark from the address of our previous President, General Pitt Rivers, a remark which has been waiting twenty-three years for further notice. He said, 'Nor is it unimportant to remember that anthropology has its practical and humanitarian aspect; and that as our race is more often brought into contact with savages than any other, a knowledge of their habits and modes of thought may be of the utmost value to us in utilising their labour, as well as in checking those inhuman practices from which they have but too often suffered at our hands.'

The foremost principle which should be always in view is that the civilisation of any race is not a system which can be changed at will. Every civilisation is the growing product of a very complex set of conditions, depending on race and character, on climate, on trade, and every minutia of the circumstances. To attempt to alter such a system apart from its conditions is impossible. For instance, whenever a total change is made in government, it breaks down altogether, and a resort to the despotism of one man is the result. When the English Constitution was swept away, Cromwell or anarchy was the alternative: when the French Constitution was swept away, Napoleon was the only salvation from anarchy. And if this is the case when the externals of government alone are altered, how much more is it the case if we attempt to uproot the whole of a civilisation and social life? We may despotically force a bald and senseless imitation of our ways on another people, but we shall only destroy their life without implanting any vitality in its place. No change is legitimate or beneficial to the real character of a people except what flows from conviction and the natural growth of the mind. And if the imposition of a foreign system is injurious, how miserable is the forcing of a system such as ours, which is the most complex, unnatural, and artificial that has been known; a system developed in a cold country, amid one of the hardest, least sympathetic, and most self-denying and calculating of all peoples of the world. Such a system, the product of such extreme conditions, we attempt to force on the least developed races, and expect from them an implicit subservience to our illogical law and our inconsistent morality. The result is death; we make a dead-house and call it civilisation. Scarcely a single race can bear the contact and the burden. And then we talk complacently about the mysterious decay of savages before white men.

Yet some people believe that a handful of men who have been mutilated into conformity with civilised ideals are better worth having than a race of sturdy independent beings. Let us hear what becomes of the unhappy products of our notions. On the Andaman Islands an orphanage, or training school, was started and more than forty children were reclaimed from savagery, or torn from a healthy and vigorous life. These were the results. 'Of all the girls two only have continued in the Settlement, the other survivors having long since resumed the customs of their jungle homes. . . . Physically speaking, training has a deteriorating effect, for of all the children who have passed through the orphanage, probably not more than ten are alive at the present time, while of those that have been married, two or three only have become parents, and of their children not one has been reared.'[1] Such is the result of our attempts on a race of low but perfect civilisation, whom we eradicate in trying to improve them.

Let us turn now to our attempts on a higher race, the degenerated and Arabised descendants of a great people, the Egyptians. Here there is much ability to work on, and also a good standard of comfort and morality, conformable to our notions. Yet the planting of another civilisation is scarcely to be borne by them. The Europeanised Egyptian is in most cases the mere blotting paper of civilisation, absorbing what is most superficial and undesirable. The overlaying of a French or English layer on a native mind produces only a hybrid intellect, from which no natural growth or fertility can be expected. Far the more promising intellects are those trained by intelligent native teachers, where as much as can be safely assimilated has grown naturally as a development of the native mind.

Yet some will say why not plant all we can? what can be the harm of raising the intellect in some cases if we cannot do it in all? The harm is that you manufacture idiots. Some of the peasantry are taught to read and write, and the result of this burden which their fathers bore not is that they become fools. I cannot say this too plainly: an Egyptian who has had reading and writing thrust on him is, in every case that I have met with, half-witted, silly, or incapable of taking care of himself. His intellect and his health have been undermined and crippled by the forcing of education. With the Copt this is quite different: his fathers have been scribes for thousands of years, and his capacity is far greater, so that he can receive much more without deterioration. Observation of these people leads to the view that the average man cannot receive much more knowledge than his immediate ancestors. Perhaps a quarter or a tenth more of ideas can be safely put into each generation without deterioration of mind or body; but, at the best, growth of the mind can in the average man be but by fractional increments in each generation, and any large increase will surely be deleterious to the average mind, always remembering that there are exceptions both higher and lower. Such a result is only what is to be expected when we consider that the brain is the part of man which develops and changes as races reach a higher level, while the body remains practically constant through ages. To expect the brain to make sudden changes of ability would be as reasonable as to expect a cart-horse to breed racers, or a greyhound to tend sheep.

[1] E. H. Man, 'On the Andaman Islands,' *Anthrop. Jour.*, xiv. 265.

Man mainly develops by internal differences in his brain structure, as other animals develop by external differences in bones and muscles.

What, then, it may be asked, can be done to elevate other races? How can we benefit them? Most certainly not by Europeanising them. By real education, leading out the mind to a natural and solid growth, much can be done; but not by enforcing a mass of accomplishments and artificialities of life. The general impression in England is that reading, writing, and arithmetic are the elements of education. They might be so to us, 'in the foremost files of time,' but they assuredly are not so to other races. The complex ideas of connecting forms and sounds is far too great a step for many brains; and when we succeed, to our delight, in turning out finished readers, Nature comes in with the stern reply, 'Of their children not one has been reared.' Our bigoted belief in reading and writing is not in the least justified when we look at the mass of mankind. The exquisite art and noble architecture of Mykenæ, the undying song of Homer, the extensive trade of the Bronze Age, all belonged to people who never read or wrote. At this day some of my best friends—in Egypt—are happily ignorant of such accomplishments, and assuredly I never encourage them to any such useless waste of their brains. The great essentials of a valuable character—moderation, justice, sympathy, politeness and consideration, quick observation, shrewdness, ability to plan and pre-arrange, a keen sense of the uses and properties of things—all these are the qualities on which I value my Egyptian friends, and such qualities are what should be evolved by any education worth the name. No brain, however humble, will be the worse for such education which is hourly in use; while in the practical life of a simple community the accomplishments of reading and writing are not needed for perhaps a week or a month at a time. The keenest interest is taken by some races, and probably by all, in geography, modes of government, and social systems; and in most countries elements of hygiene and improvements in the dwellings and arts of life may be taught with the best results. There is therefore a very wide field for the education of even the lowest races, without throwing any great strain on the mental powers. And it must always be remembered that memory is far more perfect where a less burden of learning is thrown on the mind, and ideas and facts can be remembered and brought into use more readily by minds unstrained by artificial instruction.

The greatest educational influence, however, is example. This is obvious when we see how rapidly the curses of our civilisation spread among those unhappily subjected to it. The contact of Europeans with lower races is almost always a detriment, and it is the severest reflection on ourselves that such should be the case. It is a subject which has given much room for thought in my own dealings with the Egyptian peasant to consider how this deleterious effect is produced, and how it is to be avoided. Firstly, it is due to carelessness in leaving temptations open to natives, which may be no temptations to ourselves. To be careless about sixpences is as demoralising to them as a man who tossed sovereigns about the street would be to us. Examples of carelessness in this point are among the worst of influences. Another injury is the inducement to natives to imitate the ways and customs of Europeans without reason. Every imitation, as mere imitation, is a direct injury to character; it teaches a man to trust to some one else instead of thinking for himself; it induces a belief in externals constituting our superiority, while foresight and self-restraint are the real roots of it; and it destroys all chance of any real and solid growth of character which can flourish independently. A native should always be discouraged from any imitation, unless he attempts it as an intelligent improvement on his own habits. Another sadly common evil is the abuse of power, which lowers that sense of self-respect, of honour, and of honesty which can be found in most races. If a man or a government defrauds, it is but natural to the sufferer to try to recompense himself by any means available; and thus an interminable system of reprisals is set up. Such is the chronic state of the East at present among the more civilised races. The Egyptians are notorious for their avarice, and are usually credited with being inveterate money-grabbers; yet no sooner do they find that this system of reprisals is abandoned and strict justice maintained, than they at once respond to it; and I may say that when confidence has once been gained it is almost as common to find a man dispute an account against his own interest as for himself, and scarcely ever is any attempt made at false statements or impositions. Such is the healthy response to straightforward dealing with them.

It is therefore in encouraging a healthy growth of all that is worthy and good in the existing systems of lower civilisation, in repressing all mere imitations and senseless copying, and in proceeding on a rigorously just yet genial course of conduct, that the safe and true line lies for intercourse with inferior or different civilisations.

And, lastly, the question comes home to us, In what way is this practical anthropology to be fostered? It is so essentially important to us as a race that we should take good care that it is understood. Whether it be a question of interference with the customs of higher races, as the Hindu, or of lower savages, as the Australian, momentous questions may often depend on public opinion amongst a mass of people in England who have no conception at present of the race with whom they are dealing. And still more needful is it for those who take part abroad in the governing of other races to have a wide view of the character of various civilisations. Until the present generation there have been two great educative influences on the view of life taken by Englishmen, the Old Testament and the Classics. So long as a boy had his ideas formed in contact with Oriental polygamy and Greek polytheism, he was not in danger of undue narrowness in dealing with the Muslim or the Hindu; but with the pressure of modern requirements both of these excellent views of other civilisations are being crowded out, and we meet men now to whom the world's history began when they were born. There is great danger in such ignorance. All the painful and laborious experiments in social and political problems during past ages are ignored, rash trials are made on lines which have been repeatedly proved to be impossible, and real advance in any direction is thwarted by useless repetitions of the well-known failures of the past.

It is the business of anthropology to step in, and make a knowledge of other civilisations a part of all decent education. In this direction our science has a most important field before it, at least as valuable as geography or history, and far more practical in developing ideas than many of the smatterings now taught. To present a view of another civilisation, we require to give an insight into the way of looking at the world, the modes of thought, the aims in life, the checks and counter-checks on the weaknesses of man, and the construction of society and of government, in each case. The origin and utility of the various customs and habits need to be pointed out, and in what way they are reasonable and needful to the well-being of the community. And above all, we ought to impress on every boy that this civilisation in which he grows is only one of innumerable experiments in life that have been tried; that it is by no means the only successful one, or perhaps not the most successful, that there has been; that there are many other solutions of the problems of community and culture which are as good as our own, and that no one solution will fit a different race, climate, or set of conditions.

How such a sense of proportion in the world is to be attained, and what course of instruction will eradicate political fanaticism, and plant a reasonable tolerance of other forms of civilisation, is the problem before us as practical anthropologists. The highest form of this perception of other existence is reached in the best history—writing or fiction, which enables the reader to strip himself for the time of his prejudices and views of life, and reclothe the naked soul with an entirely different personality and environment. Very few writers, and those only in rare instances, can reach this level; it needs consummate knowledge, skill, sympathy, and *abandon* in the writer, and if without these, it is neither accurate nor inspiring. The safer course is to carefully select from the best literature of a civilisation, and explain and illustrate this so as to leave no feature of it outside of the reason and feelings of the reader. Here we run against the special bigotry of the purely classical scholar, who looks on ancient literature as a peculiar preserve solely belonging to those who will labour to read it in its original dress. No one limits an acquaintance with Hebrew, Egyptian, or Arabic authors to those who can deal with those tongues; and Greek and Latin authors ought to be as familiar to the English reader as Milton or Macaulay. To say that because it is impossible in a business education to give several years to a working knowledge of ancient languages, that therefore all thought written in those languages shall be a sealed book, is pedantry run mad. A few months, or even weeks, on translations will at least open the mind, and give an intelligent sense of the variety and the standpoint of the intellect of the past. And such a course is certainly better than the total ignorance which now prevails on such lines where the classics are not taught.

What seems to be the most practical course would be the recognition of civilisation or social life as a branch of general reading to be stimulated in schools, and encouraged by subsequent inquiry as to the extent to which it is followed and understood, without making it an additional fang of the examination demon.

The books required for such reading should cover the life of Greece, Rome, Babylon, Egypt, and Mexico in ancient times; and China, India, Persia, Russia, Spain, and one or two low civilisations, such as the Andamans and the Zulus, in modern times. Neither histories nor travels are wanted for this purpose; but a selection of the literature which shall most illustrate the social life and frame of the community, with full explanation and illustrations. We need not to excite wonder, astonishment, or disgust; but rather to enable the reader to realise the daily life, and to live in the very minds of the people. Where no literature is available, a vivid study of the nature of the practical working of their civilisation should take its place.

Such is the practical scope of anthropology in our daily life, where it needs as much consideration and will exercise as great an influence as any of the other subjects dealt with by this Association.

The following Papers were then read:—

1. *On a Recent Discovery of the Remains of the Aboriginal Inhabitants of Jamaica. By* Sir W. H. Flower, *K.C.B., F.R.S.*

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2. *On Skulls of Neolithic Invaders of Egypt. By* Professor W. M. Flinders Petrie, *D.C.L., LL.D.*

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3. *On Neolithic Invaders of Egypt. By* Professor W. M. Flinders Petrie, *D.C.L., LL.D.*

FRIDAY, SEPTEMBER 13.

The following Papers and Reports were read:—

1. *Stone Implements in Somaliland. By* H. W. Seton-Karr.

My first discovery of flint chipped spear-heads, knives, and scrapers was in the winter of 1893–4, on my return to the coast from lion-hunting in the interior. A few of those I then picked up are now in the British Museum; a few I gave to the Earl of Ducie's collection, and the remainder I retained for myself. This winter, 1894–5, on my return from lion-hunting I again traversed, without halting, the district to which they appear to me to be confined, and obtained several thousands by diligently searching for them in those places where my previous experience suggested to me that they would probably be found. Of this large number, however, only about one hundred are really symmetrically chipped as spear-heads. I also gathered a number of cores, chips and flakes, knives, and scrapers. The places where they abound in the district alluded to were invariably of one character. In the first place the district was distinguished by the presence of flint nodules upon the surface, so that these ancient peoples, with whom this place was apparently a manufactory, had the materials ready to their hands.

I observed next that they were more numerous as one approached a well or the river beds in which the wells are dug.

Also I inferred that the people who made them seemed to be timid, or in a state of constant warfare with the surrounding tribes (as the Somalis are to this day), because the spots which seem to have been chosen as factories for the noisy operation of breaking up the flint nodules and shaping them, were usually retired places surrounded by low hills, which would prevent the sound from travelling far. There was also generally a watercourse with steep sides, along which persons could escape unseen if surprised by people coming suddenly over the surrounding ridges.

The implements were most numerous in the vicinity of this central watercourse. The ground had always a very gentle fall, so that the heavy showers which constitute the rainfall in Somaliland would wash away the sandy soil, and yet keep the stones lying free and clean upon the surface, in which position they were always found.

Also there were generally no other stones upon the surface besides these worked flints.

There is another point which I cannot explain, though the reason may be simple; it is that there was never any vegetation upon the spot upon which I found these implements scattered, excepting a few scraggy mimosa bushes.

This was not owing to my not having searched the surface where it was partly covered with plants, for I was always on the alert to detect the presence of worked flints while in pursuit of game. I trained some of my men to discover these spots, which were not hard to find, being, as I said, bare of vegetation, and the shining surfaces of these flints reflecting the sunlight and covering the ground, sometimes for the space of half an acre. I also trained them to pick up and bring me worked flints. Still, I often found fine specimens on ground which they had already searched.

It is my intention to return once more to this district this winter, which will make my seventh expedition into equatorial oriental Africa.

Finally, out of all my specimens, I think there is not one absolutely perfect; all seem either damaged or unfinished.

Sometimes I found an unfinished spear-head on the ground, surrounded by a mass of flakes and chips, as though the people had dropped their work, and, carrying with them all their perfect weapons and belongings, had fled, never to return.

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2. *On Flint and Metal Working in Egypt.* *By* Professor W. M. Flinders Petrie, *D.C.L., LL.D.*

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3. *On Flint Implements with Glacial Markings from the North of Ireland.* *By* W. J. Knowles, *M.R.I.A.*

The author referred to his having exhibited and described a large pear-shaped flint implement with glacial markings at the Southport meeting in 1883. The flake-marks did not show evidence of bulbs, and the artificial character of the implement was questioned. The author believed that the bulb-marks may have been removed by dressing, but he now produced specimens which were similarly scratched, and showed undoubted marks of bulbs and other evidence of being artificial productions. They were found at Kilroot, Larne, and Island Magee, on the shores of Antrim, and though probably lastly derived from the raised-beach gravels found at those places, he believed they had originally come from a glacial formation which had been removed by denudation.

4. *Report on the Plateau Flints of North Kent.*—See Reports, p. 349.

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5. *On Graving Tools from the Terrace-Gravels of the Thames Valley.* *By* H. Stopes.

The author exhibited and described sixty-four stones worked and used by Palæolithic man. These were selected from many more of similar types. They have all been found in the gravels resting on the Chalk, on the Kentish side of the Thames, at levels ranging from 70 feet to 105 feet above O.D. from the various pits occurring between Higham and Dartford.

The series consists of seven distinct forms or groups:—

1. Ordinary flakes with used and worked ends ranging from $\frac{3}{4}$ inch to 8 inches long.

2. Fragments or large flakes worked all round but brought to a spur or point, chiefly left-handed, and varying much in shape and size. The points are straight or curved, pointed and duck-billed.

3. Cores similar to 2, but with carefully-formed points, indicating much wear and use, chiefly left-handed.

4. Split flints or wide flakes made nearly square, with one, two, or more points at the corners. Wear on sides indicates use as spokeshaves.

5. Ovate, well-formed tools, or large flakes with strong sharp spur or point at sides or end. These run in size up to 5 inches in width by 7 inches in length.

6. Well-worked tools of the ordinary axe (or *hache*) shape, with well-defined point at sharp or thin edge. In many this point could not be accidental. In others a broken axe has had a point rechipped in such a position that it would not be able to be readily or conveniently used as an axe.

7. Nodules of flint very slightly worked at one end, chiefly with broad points of the duck-bill type. These stones suggest extensive use of ivory, bone, wood, shell, leather, and all such materials, together with a higher degree of civilisation and refinement than is commonly accorded as yet to Palæolithic men.

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6. *On Palæolithic Projectiles.* *By* H. Stopes.

Ninety specimens were exhibited of stones, chiefly flint, found in the recognised Palæolithic gravels in Kent, Bedford, and Suffolk. These ranged from 8 in. in diameter to less than 1 in., and from 3 in. in thickness to $\frac{3}{8}$ in., and in weight from over 3 lbs. to half an ounce.

The suggested use was throwing by hand, from a cleft-stick, or with a sling; preferably the latter, as some could not be held in a cleft stick. Many are very rough stones resembling cores, but are carefully fashioned to shape, and some have obviously been used. The author compared them with some found in the vicinity of Neolithic settlements, chiefly at a distance of from 70 to 150 yards outside the camp.

The majority of the stones are circular and flat, the thickness equalling from one-third to one-half the diameter. Some are carefully worked all over.

One series, called gyrators, are very carefully shaped to a thin oval form that possesses a half-spiral twist. The author suggested that they may have been slung, and in flight they might describe an ellipse, after the fashion of a boomerang. Some of these were too thick at the edges to permit of use as flaying-knives.

Over 20 per cent. of the projectiles yet found by the author consist of broken tools. The larger stones are frequently the butt-ends of axes, and the smaller have often apparently been tips. Three shown were broken eoliths from the upper plateau-gravels in Kent, that had been reworked and chipped by men prior to deposition at 105 feet above O.D. in the Swanscombe gravels. One of these is heavily patinated and waterworn on its older faces. When being struck into its present form a fine bulb of percussion was made, which is not waterworn.

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7. *The Senams, or Megalithic Temples of Tarhuna, Tripoli.* *By* H. Swainson Cowper, *F.S.A.*

This remarkable series of sites, which hitherto has been practically unknown, formed the sole object of the author's short journey in March. In all, nearly sixty sites were visited, and photographs of them taken. The largest number were found on a green plateau in the Tarhuna hills, but others exist in the surrounding wadis. In some places, indeed, they are so numerous that there are few hill-tops which do not bear traces of one of these temples, so that the author had to content himself with an examination of those which seemed most important. In most cases were found large rectangular enclosures of excellent masonry, though generally very ruinous, and often subdivided by lines of short square columns, occasionally surmounted by rudely designed but excellently worked capitals. Within the enclosure walls, or in line with them, were always to be found large Megalithic structures resembling the Stonehenge trilithons, but the jambs of which are often formed of two or three stones instead of one. These (the Senams proper) are carefully dressed on the side facing the enclosure, and in the jambs are singular square perforations and angle-cut holes, which appear to have been formed to support wooden structures.

The Senams rest on footing stones, and vary in height from 6 to 15 feet; but the average width between the jambs is only 16½ inches. In front of some were found massive stone altars, carefully grooved, and flush with the ground. A few sculptures, the subjects of which are Phallic and show Roman influence, were also noticed, in one case a Senam itself being thus ornamented. There is, indeed, much evidence to show that the Romans occupied and utilised these sites without knocking down the Senams or destroying the form of worship. Roman work is mixed up in nearly every case with the work of the Senam builders.

A feature worth notice is the existence of carpentry forms, which would point to the district having at one time been densely timbered; and to the destruction of these woods (probably by the Arabs) is no doubt due the waterless and poverty-stricken condition of the country at this day. It is to be noticed, that if we except the Stonehenge trilithons, there appear to be no other Megalithic remains, even in Mediterranean countries, with which we can compare the Tripoli series or which show an equal mastery in the art of masonry.

In most cases the Senams appear to have stood free in their enclosures, and were no doubt symbolical and connected with rites of some sort. It is remarkable that many Babylonian seals show a figure exactly like a Senam placed in the rear of an altar before which stands an adoring priest. It seems possible indeed that in the Senams we have symbolic effigies akin to the 'Asherah' so often alluded to in the Old Testament, and which was worshipped in connection with Molech and Baal.

Asherah, the symbol of the goddess of fertility, would probably take some such form, and from such a worship sprang no doubt the widely spread customs of squeezing between columns and stones to cure diseases. Further evidence in favour of these being temples of a form of Baal worship may be found in their situations, always on hill-tops, essentially 'high places,' and possibly also in the character of the carvings.

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8. *Report on the Kitchen Midden at Hastings.*—See Reports, p. 500

SATURDAY, SEPTEMBER 14.

The following Reports and Papers were read:—

1. *Report on the North-Western Tribes of Canada.*—See Reports, p. 522.

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2. *The Samoyads of the Arctic Tundras.*
By Arthur Montefiore, *F.G.S., F.R.G.S.*

Distribution of the Samoyads.—This primitive group of the Ural-Altaic family may be found within an area of great extent and very various nature. Samoyads may still be observed on the northern slopes of the Altai range; they still dwell in the afforested valleys of the Yenisei and the Ob, and they continue to thrive on the frozen treeless plains of Siberia and Arctic Russia. From the ultimate sources of the Yenisei in the heart of Asia, they spread northward until their advance is stayed by the waters of the Arctic Ocean. From the Khatanga river in the far east they reach westward into Europe, even to the shores of the White Sea. And we have the authority of Mr. F. G. Jackson (*The Great Frozen Land*, cap. vi.) for saying that they are still migrating westward—a small group having recently settled in Russian Lapland, and already contributed to the modification of Lapp habits and fashions.

The Arctic Samoyad.—The Samoyad of the Arctic Tundras is the least changed, and perhaps the most interesting of the whole family. Until recently less has been known of his ways and means, of his ideas and morality, of the country in which he lives, and the adaptation of himself to his environment, than of the other branches of the same group. The very impoverishment of his resources has calculated to make him more characteristic and distinct.

Ethnology.—Undoubtedly the term Ural-Altaic is conveniently applied to the four great Mongoloid groups—the Tungus, the true Mongols, the Turks, and the Finns; and the Finnic group may also be properly regarded as made up of the Ugrian races, the Permian, the Bulgarian, the true Finns, and the Samoyads. From another point of view, however, it would be well to include the Samoyads in the Finnic subdivision. For the Samoyads are more nearly allied to the Finns than Ugrians, Permians, and Bulgarians; their speech is Finn, their customs related: and the true Finns, as well as the quasi-Finns, possess in numerous instances survivals and traces of what is to this date in full development among the Samoyads.

Name of Samoyad.—This can be shown to be not of Russian but of Permian and even Finnic origin, and to mean not 'eaters of themselves,' or 'cannibals,' but 'swamp-dwellers.' The old Russian word for them, then, does not suggest cannibalistic custom, but may be translated 'eaters of raw flesh,' which they are to this day.

Language.—Closely allied to the Finnic tongue, the Samoyad speech shows, of all the Ural-Altaic languages, the highest development in agglutination. This is carried so far that it almost reaches inflection. Samoyad, indeed, may be regarded as a nexus between the inflexional Indo-Germanic and the agglutinative Mongolian.

Religious Ideas.—Although professing Christianity and the Greek Church [owing to the zeal with which every Russian promotes the cause of his Church], the Samoyads have not relinquished faith in their old gods, and still cherish a crypto-paganism. The impersonal *Num*, creator of the universe, dwells in the heavens; the rain and snow, heat and cold, thunder and lightning, are expressions of his care for the men he created, as well as of his moods. The sun is his highest form of manifestation; the wide arch of the sky bears witness to the immensity of his being; the countless stars to his far-seeing and intimate knowledge. More material, however, is the idea that the coloured bands of the rainbow form the border of his robe.[1] Veneration of the supernatural is also shown in the cult of the natural: curiously shaped trees, large stones, somewhat resembling the human form, and even roughly shaped stakes of wood, are locally revered. This veneration is also extended to rude models of these stakes, which are made sufficiently small to carry about, and are called *Chaddi.*

Morality.—As a rule, and, of course, wherever they are professed Christians, the Samoyads are husbands of one wife. In Yalmal and other remote places

[1] Multi-coloured bands of cloth are inserted in the *panitsa* of the Samoyad.

two wives are not uncommon. The offence of adultery is rare, and fornication is not approved. The temperament of the Samoyad is amiable; he is hospitable, cheery, and even-tempered. Sentiment is hardly known to him, and he has no good reason, or hope of future reward for the honest or benevolent acts he performs. Idleness is often necessitated by circumstances, but the naturally active man is discernible even then. The Samoyad is capable of politeness and of sobriety, though the Russian traders do their best to destroy the latter virtue. The Samoyad is neighbourly; the young are obedient and respectful; and the old are tenderly cared for. Inexpressibly filthy in their customs, the Samoyads exhibit as a race social virtues of a high order.

Physical Appearance.—The average stature of the men is 5 ft. $1\frac{3}{4}$ in., and of the women 4 ft. $9\frac{5}{8}$ ins. The head is wide and low; the face broad and short; the forehead usually receding; the eyebrows pencilled and arched; the nose is flat, but straight; the prominence of the mouth is not marked, but the lips are thick. The eyes are wide apart and oblique; their colour is black and their size small; the lids are full. The colour of the skin is yellowish-brown, while the cheeks of young people are frequently ruddy. The hair, which is cylindrical and coarse, is jet black. The moustache is always slight, and there usually depends from the chin a weak thin beard.

The highest English authority on the Samoyads is Mr. F. G. Jackson, and in his work on the subject (*The Great Frozen Land*) he tells us that the physique of the Samoyad is sturdy: the shoulders being broad, the legs stout, though short, and the arms highly developed. The head is out of proportion to the body in its largeness, and the neck is short and thick. The sense of hearing is extremely acute, and the sight remarkably keen; the power of grasp is considerable. The Samoyads run well, and are capable of enduring great fatigue, and sustaining arduous exercise for a long period.

Occupations.—These are chiefly hunting and fishing. To enable them to do the former, they break and train the reindeer until these animals have reached a high stage of excellence as draught beasts. The sledge, too, is perfectly adapted to the physical difficulties presented by the Tundra. The reindeer is the 'staff of life' on the Tundra. Its skin makes the tent or 'choom' which fends the wild weather from his master; it also forms the chief fabric of his clothing. Its body constitutes the main food of the Samoyad, and its hide and sinews his harness, cordage, and thread. It is the only animal which is fitted to draw burdens across the Tundra, a quaking bog in summer, a howling frozen plain in winter. In the latter season, the Samoyad hunts, attacks, and snares the white bear, brown bear, sable, fox, lynx, and other fur-bearing animals; in summer, he catches enormous numbers of birds—geese, swans, duck, &c. He brings his furs to the market before the melting of the snow makes it impossible for him to take heavy loads across the Tundra; but a contingent is usually left behind to complete the season's harvest. These the Samoyad rejoins before the rivers burst free from the ice, and the whole country becomes an impassable swamp.

Notes on *Marriage Customs, Social Usages, Funerals, Folk-lore, Weapons* and *Instruments*, and *Costume*, were also included in the paper.

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3. *On Cannibalism.* *By* Captain S. L. Hinde.

Captain Hinde, who has been travelling and fighting for some years in the Congo basin, and has therefore had many almost unprecedented opportunities of observing the natives, gave the following information with regard to cannibalism:—

Almost all the races in the Congo basin practise cannibalism, and though in some parts it is prevented by the presence of white civilisation, in others it seems to be on the increase. An extensive traffic in human flesh prevails in many districts, slaves being kept and sold as an article of food.

The different tribes have various and horrible methods of preparing the flesh for eating; in some instances, before the death of the victim, certain tribes of the Bangala race themselves acknowledge that they break the arms and legs of the victim, and place the body, thus mutilated and still living, in water for two or three days, on the supposition that this pre-mortem treatment renders the flesh more palatable. There are also distinct tribal preferences for various parts of the body, and it is remarkable that, contrary to an ignorant yet very generally accepted theory, the negro man-eater never eats flesh raw, and certainly takes human flesh as food purely and simply, and not from any religious or superstitious reasons.

4. *Report on the Physical and Mental Defects of Children.*

See Reports, p. 503.

5. *Report on Anthropometric Measurements in Schools.*

See Reports, p. 503.

MONDAY, SEPTEMBER 16.

The following Papers and Report were read:—

1. *Horns of Honour and Dishonour and Safety. By* F. T. ELWORTHY.

2. *On the Origin of the Dance. By* MRS. LILLY GROVE, *F.R.G.S.*

The study of the history of the dance throws a light on manners and customs of various races, on connection between nations geographically remote, and especially on primitive religion.

After a long study of the subject, the conclusion arrived at is that most dances were once a form of worship, or at least a form of magic. Many myths relate that the deities not only delighted in seeing the dance, but also enjoyed performing in it. Promises of a heaven in which there will be much dancing and many dancers are held out by several religions, even by monotheist ones, and even by some Christian Fathers. All ritual dances are grave, reverent, and symbolical of joy, or gratitude, or sorrow. The object of this Paper is to point out that most dances have a sacred origin, and to show what survivals we have of these dances. Three forms are chosen in support of the theory—the weapon dances, the ritual dances, and the funeral and death dances.

Weapons were once worshipped and held sacred, hence numerous sword dances in all parts of the globe—in the Himalayas, in the Andes of Bolivia, in Scotland, in Spain, in Scandinavia, generally in mountain districts.

Ritual dances are so numerous that a choice has to be made, and only those of Christian worship will be considered; among those the *Los Seises* dance of the Seville Cathedral and the dancing procession of Echternach, which latter probably arose from a penitential vow. Medicine dances belong generally to the ritual, for the mystery or medicine man is usually also the priest.

Funeral dances are world-wide among pagans and Christians; they originate in what the author of ‘The Golden Bough’ calls sympathetic magic, they are often a form of exorcism, or of propitiation of death, or arise from fear of the soul of the departed. The dance being a form of worship of the Deity, eventually also becomes a form of reverence towards the departed.

Pagans mostly honour aged men, chiefs, and priests by such a funeral dance, while Christians perform funeral dances to rejoice over the death and consequent delivery from evil of a young person who has died in a state of innocence. Parallels have been made between the ‘Lemuric’ dances of the Roman Empire and the dance *macatre*, but the parallel is not complete; in England the latter was called the ‘Doleful Dance,’ also the ‘Shaking of the Sheets.’ Churchyards used to be the most favourite places for the dance, and the Welsh danced in their graveyards after the conclusion of the sermon until quite recently. At one time of the world's history the dance must have been exclusively an act of homage towards the Deity, or the ministers and earthly representatives of the Deity.

As nations grow out of infancy and become more artificial and affected, the dance loses in significance.

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3. *Report of the Ethnographical Survey Committee.*—See Reports, p. 509.

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4. *On Ethnographical Observations in East Aberdeenshire.*[1] *By* J. Gray, *B.Sc.*

In August last, observations were made by the Buchan Field Club on the people at the Mintlaw Gathering, in the centre of north-east Aberdeenshire. At the entrance, the colour of hair and eyes, and shape of nose of 2,309 males and 649 females were noted. In a tent in the grounds measurements were made of the height (standing and sitting), and length and breadth of head, of 169 adult native males. The people belonged to the agricultural class. The gate observations gave the following gross percentages:—*Hair*—fair 9·7, red 5·7, brown 64·4, dark 20·2; *eyes*—dark 26·2, medium 49·0, light 24·8; *noses*—straight 56·4, concave 19·9, high bridge or Roman 14·8, sinuous or wavy 6·7, and aquiline or Jew 2·2.

In the gate observations, it was found that in the majority of cases light eyes were associated with fair hair, and dark eyes with dark hair. The ratio of light to dark eyes changed gradually from fair hair, through red and brown hair, to dark hair. On analysing the combinations of hair colour with the different types of noses, it was found that the sum of the fair and red hair associated with each type of nose was, in each case, almost the same, but the number of cases with dark hair was least with concave noses and greatest with aquiline noses. This appears to indicate that one of the primitive race-types had fair hair, light eyes, and a concave nose. This agrees with the Germanic or Canstadt type. The extreme cephalic indexes obtained in the tent measurements were 86 and 70; but the most usual indexes were 77 and 79. The diagrams of head breadths and lengths, heights, and cephalic indexes all show two principal maxima near the centre, with at least two smaller maxima at the sides. The prevailing type in the district has brown hair, medium eyes, and a straight nose; but this appears to be a mixed type, sprung from the mixture of a dolichocephalic fair race with two dark races, one dolichocephalic and tall, and the other brachycephalic and short.

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5. *On the Suffolk Dialect.* *By* C. G. de Betham.

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6. *General Conclusions on Folk-lore.* *By* Edward Clodd.

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7. *Illustrations of Folk Lore.* *By* Professor A. C. Haddon.

[1] A full account will be published in the *Transactions* of the Buchan Field Club.

TUESDAY, SEPTEMBER 17.

A Discussion on interference with the civilisation of other races was opened by the reading of the following Paper: [1]—

1. *Protest against the Unnecessary Uprooting of Ancient Civilization in Asia and Africa.* *By* ROBERT N. CUST, *LL.D.*

The tendency on the part of Europeans, and English and French especially, to denationalise the customs of populations which come under their influence, is to be deplored, so long as those customs are not contrary to the moral laws of the human race. It is not in any way evident that the customs of European nations are in themselves better than those of the Asiatic and North African; as regards the barbarous races of Africa south of the Sahara, Oceania, and North America the argument is not pressed, but is restricted to those regions where the inhabitants have an ancient civilization of their own, such as Persia, India, China, and Japan.

Any forcible change of dress, language, social practice, and municipal law, is to be deplored: the progress of education, civilization, and contact with nations in a superior state of culture will do its own work insensibly without wounding the self-respect of ancient nations: the argument applies particularly to British India. Nothing can be more prudent and rational than the action of the British Government, but associations of irresponsible persons are found in Great Britain interfering with the prejudices of a great nation of nearly three hundred millions, which may eventuate in very serious consequences. The study of the gradual development of an Asiatic society by voluntary adoption of European influence will be most interesting to the student of anthropology.

The following Papers were read:—

2. *The Light thrown on Primitive Warfare by the Languages and Usages of Historic Times.* *By* Rev. G. HARTWELL JONES, *M.A.*

The institution of war dates from the highest antiquity; nor was it an unmitigated evil. It deeply influenced civilisation. Early Greece and Italy may be taken as types of other 'Aryan' countries, and the evidence they afford can be supplemented by evidence from other quarters.

The sources of evidence are (1) the dead languages, especially Greek and Latin; (2) survivals among civilised races and the customs of backward savages to-day; all of which point to the evolution of civilisation in Greece and Italy from a primitive barbarism.

The influence of war was far-reaching. It left a deep impression upon (1) *language*, as is seen in the words common to different branches of the 'Aryan' stock; (2) *society*: for example, marriage and social distinctions; (3) *religion*. Religious feuds were often the occasion of war; the gods intervened in these struggles, as is seen from the prominent place occupied by war-gods in the mythologies of 'Aryan' races.

The history of primitive warfare exhibits three stages of growth. It is impossible to differentiate them clearly, but we may distinguish war (1) in the *hunting* stage. Here the methods would be of the crudest kind—stones, charred stakes, horns, and a rude bow and arrows were employed; battles were marked by cruelty and treachery. (2) The *pastoral* stage. Here the ox figured frequently; it was often the cause of hostilities, as witness some names for battle. (3) With the rise of *agriculture* war assumed a fiercer aspect, greater issues being at stake.

[1] An account of the discussion has been published at the office of the *East Anglian Daily Times*, Ipswich.

Within the limits of one country there was sometimes a *variety of usage*, according to the different influences, mainly geographical and racial, to which its parts were subjected. Language reflects this diversity. Primitive warfare was *religious* in its character, war-gods interposing, each with champions and totems. The early Latin god Janus is a good instance of the survival of animism down to a late time.

The *causes* of primitive warfare were diverse. At first it was carried on chiefly for (1) *self-defence*, for protection of food supplies, shelter, and wives. Animals and pastures were frequently grounds of contention. In this respect Sanskrit is very instructive. (2) Wars of *aggression* do not fall much within the scope of our inquiry.

The earliest wars were characterised by cruelty. Those who were incapacitated from fighting by age were put to death, sometimes voluntarily.

Even as late as the time of Homer *physical force*, rather than skill, distinguished the warrior and decided battles. Bodily strength, therefore, marked out men for leadership, and a nobility gradually grew up from the warrior class.

Battles were preceded by *sacrifices*, and it is significant that these were performed by the chieftain, who combined in his person functions afterwards separated.

The nature of the country dictated the *tactics*, according as the ground was swampy, rocky, or wild. At first only foot-soldiers were employed; chariot-driving followed; horse-soldiers were a more recent development. Although there are indications even in the Vedic hymns of riding being known, yet as late as Homer's time it was rather a special art than a common practice.

Relationship was the basis of *arrangement* on the battle-field.

The usages after the conclusion of hostilities are instructive. (1.) *Reverence towards the gods.* They were invited to desert, and their attendants were protected from violence. (2.) *Males* were ruthlessly put to the sword; *women and children* were treated barbarously. Indignities were heaped upon the conquered, and bodies were sometimes mutilated. It is impossible to resist the conclusion that *human sacrifice* was practised.

An examination of the material on this subject establishes several interesting points—the religious character of early civilisation, the divergence of the branches of the 'Aryan' family of races, and their development in different directions.

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3. *On a Palæolithic Skeleton from the Thames Valley.* *By* Dr. J. G. Garson.

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4. *On the Skulls of the New Race in Egypt.* *By* Dr. J. G. Garson.

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5. *On the Andamanese.* *By* Maurice Portman.

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6. *On the Eskimo.* *By* F. Linklater *and* J. A. Fowler.

WEDNESDAY, SEPTEMBER 18.

The following Papers and Reports were read:—

1. *The Neolithic Station of Butmir.* *By* Dr. R. Munro.

The author, as member of the Congress of Archæologists and Anthropologists held at Sarajevo in August of last year, had an opportunity of inspecting the remarkable Neolithic station of Butmir, which forms the subject of this communication. It is situated in the plain of Ilidze, some eight miles to the west of Sarajevo, the capital of Bosnia. This plain, which extends for about seven miles in length and four or five in breadth, is composed of alluvial materials brought down from the surrounding mountains by rain and a number of streams which here meet, and it is therefore highly probable that in former times it was partially a lake-basin. In 1893, while workmen were engaged in excavating the foundations of a farm dairy in a cultivated field, it was observed that the soil turned up contained fragments of pottery, flint implements, stone axes, and other remains of a primitive people. These discoveries led to an investigation of the locality by the Government, under the supervision of the celebrated archæologist, Mr. Radimsky. A perpendicular section, 6 to 8 feet in depth, showed first a superficial layer of ordinary soil, 12 to 15 inches thick, then a series of thin beds, more or less stratified, of clay, charcoal, ashes, mould, &c., containing the above-named relics of human industry. This relic-bed, which attained a thickness of 4 or 5 feet, and a superficial area of about 5 acres, lay immediately above a bed of fine adhesive clay *in situ*—*i.e.* deposited by natural causes prior to the founding of the prehistoric settlement. By observing that on the surface of this clay there were, occasionally, irregularly shaped hollows of variable extent, Mr. Radimsky was led to formulate the opinion that they were the foundations of the huts of the first inhabitants—an opinion which gave rise to an animated controversy among the members of Congress. The deposits containing the relics formed a low mound, rising in the middle to about a couple of yards above the surrounding land. Near their surface, but below the superficial layer of soil, some burnt clay-castings of the timbers of which the huts were constructed were met with in several localities. The relics consisted, chiefly, of stone implements and fragments of pottery, all of which were interspersed uniformly throughout the *débris*.

These remains were so abundant as to suggest the idea that the inhabitants of Butmir carried on special industries for their manufacture. Stone implements—knives, arrow-heads, scrapers, polished axes (with the exception of perforated ones), and tools—were in all stages of manufacture. In regard to the perforated axe-heads, it was curiously noted that, out of twenty-five collected, only two were whole, and not a single core had hitherto been found. The material out of which they were made was not found in the neighbourhood, and hence it was supposed that the perforated axes had been imported, thus indicating a knowledge of the division of labour among these early settlers. The pottery had been ornamented with a great variety of designs, among which a few specimens with a spiral ornamentation excited much interest among the members of Congress. A special feature of this discovery is the existence of a number of small clay images, or figurines, rudely representing the human form—among them being one, a head of terra-cotta, disclosing art of a superior kind. In conclusion he observed that those who had not the opportunity of studying the original report would find a notice of the settlement and of the controversies to which it has given rise in his forthcoming work, 'Rambles and Studies in Bosnia-Herzegovina.'

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2. *On Primitive European 'Idols' in the Light of New Discoveries.* *By* ARTHUR J. EVANS, *M.A., F.S.A.*

Schliemann's discoveries at Troy first called general attention to a class of primitive images of clay, marble, and other materials. Others, of which some new and remarkable examples were exhibited, had since been found in the Ægean Islands and the mainland of Greece. In their more developed forms they appeared as nude female figures, more rarely male. Lenormant and others had sought their prototype in a nude female figure seen on some Chaldæan cylinders which, as Nikolsky has now shown, represented the Underworld Goddess Sala, an equivalent of Istar. More recently M. Salomon Reinach has boldly attempted to turn the tables and derive the Eastern type from the European side. Mr. Evans combated both these theories. That the Istar type had influenced some of the later Ægean figures was probable. But the two classes were originally independent. The Greek and Trojan figures fitted on to a primitive European family, the evolution of which could be traced from the rudest beginnings. Thracian and Danubian examples carried this diffusion to the Carpathians. Beyond this, again, a curiously parallel group—of amber, bone and stone—characterised a vast northern Neolithic province including the Polish caves and the Baltic amber coast and extending to the shores of Lake Ladoga. Attention was next called to certain recent and partly unpublished discoveries of primitive painted images in Sicily and the Ligurian caves, and after bringing them into relation with others from Bosnia and Carniola, the author showed that they had here the nearest prototypes to the Mycenæan. He exhibited a curiously rude squatting figure of Pentelic marble found near Athens—the earliest example of Attic art—and after adducing parallel examples from Thrace and the Peloponnese, claimed a cousinship for them in the so-called 'Cabiri' of what had been hitherto known as the 'Phœnician Temple' of Hagiar Kim in Malta. This primitive building was really a West Mediterranean example of a class illustrated by the primitive architecture of Sardinia, the Balearic Islands, and even our own chambered barrows. Its Libyan affinities had been noticed by Fergusson, and the so-called Cabiri, with Ægean connections on the one hand, seemed to stand in a direct relationship with the rude squatting figures of Mr. Petrie's 'New Race.' Turning to Spain, Mr. Evans called attention to a class of stone figures singularly resembling the Trojan discovered in Neolithic and early Bronze Age deposits by the brothers Siret, and to which their most recent excavations had added rich materials. Finally, as the north-westernmost example of this whole primitive class, he referred to the discovery of a whalebone 'idol' amongst Neolithic relics at Skara, in Orkney. The sepulchral relation in which these so-called 'idols' were usually discovered pointed to the conclusion that they had here an illustration of the widespread practice among primitive peoples of placing small figures in the grave as substitutes for human victims.

3. *Interim Report on Prehistoric and Ancient Remains in Glamorganshire.*

4. *Report on the Lake Village at Glastonbury.*—See Reports, p. 519.

5. *The People of Southern Arabia.* *By* J. THEODORE BENT.

The two classes of natives discussed in this paper are resident in the Hadramut and Dhofar districts of South-eastern Arabia. First, those of the Hadramut are described. Their fanaticism and complex tribal system present great difficulties to the anthropologist. Descriptions are given of the three divisions of the inhabitants—namely, the Bedouins, the Arabs proper, and the Sayyids, or hierarchical nobility. But the Bedouins and their manners and customs, as being a distinctly aboriginal race, are described with greater minuteness. Their religion is discussed, and the secret manner in which they maintain their cult is suggested as a parallel to other secret cults in other parts of the Mohammedan world.

Secondly, the district of Dhofar, the country from which the ancients obtained frankincense, is next described, and the Bedouins of the Gara tribe compared with those of the Hadramut: their manners and customs, and the general conditions under which they live, are described.

SECTION K.—BOTANY.

PRESIDENT OF THE SECTION.—W. T. THISELTON-DYER, M.A., F.R.S., C.M.G., C.I.E., Director of the Royal Gardens, Kew.

THURSDAY, SEPTEMBER 12.

The PRESIDENT delivered the following Address:—

THE establishment of a new Section of the British Association, devoted to Botany, cannot but be regarded by the botanists of this country as an event of the greatest importance. For it is practically the first time that they have possessed an independent organisation of their own. It is true that for some years past we have generally been strong enough to form a separate department of the old Biological Section D, on the platform of which so many of us in the past have acted in some capacity or other, and on which indeed many of us may be said to have made our first appearance. We shall not start then on our new career without the remembrance of filial affection for our parent, and the earnest hope that our work may be worthy of its great traditions.

The first meeting of the Section, or, as it was then called, Committee, at Oxford was held in 1832. And though there has been from time to time some difference in the grouping of the several biological sciences, the two great branches of biology have only now for the first time formally severed the partnership into which they entered on that occasion. That this severance, if inevitable from force of circumstances, is in some respects a matter of regret, I do not deny. Specialisation is inseparable from scientific progress; but it will defeat its own end in biology if the specialist does not constantly keep in touch with those fundamental principles which are common to all organic nature. We shall have to take care that we do not drift into a position of isolation. Section D undoubtedly afforded a convenient opportunity for discussing many questions on which it was of great advantage that workers in the two different fields should compare their results and views. But I hope that by means of occasional conferences we shall still, in some measure, be able to preserve this advantage.

RETROSPECT.

I confess I found it a great temptation to review, however imperfectly, the history and fortunes of our subject while it belonged to Section D. But to have done so would have been practically to have written the history of botany in this country since the first third of the century. Yet I cannot pass over some few striking events.

I think that the earliest of these must undoubtedly be regarded as the most epoch-making. I mean the formal publication by the Linnean Society, in 1833, of the first description of 'the nucleus of the cell,' by Robert Brown.[1] It seems

[1] *Misc. Bot. Works*, i. 512.

difficult to realise that this may be within the recollection of some who are now living amongst us. It is, however, of peculiar interest to me that the first person who actually distinguished this all-important body, and indicated it in a figure, was Francis Bauer, thirty years earlier, in 1802. This remarkable man, whose skill in applying the resources of art to the illustration of plant anatomy has never, I suppose, been surpassed, was 'resident draughtsman for fifty years to the Royal Botanic Garden at Kew.' And it was at Kew, and in a tropical orchid, *Phaius grandifolius*, no doubt grown there, that the discovery was made.

It was, I confess, with no little admiration that, on refreshing my memory by a reference to Robert Brown's paper, I read again the vivid account which he gives in a footnote of the phenomena, so painfully familiar to many of us who have been teachers, exhibited in the staminal hair of *Tradescantia.* Sir Joseph Hooker [1] has well remarked that 'the supreme importance of this observation, . . . leading to undreamt-of conceptions of the fundamental phenomena of organic life, is acknowledged by all investigators.' It is singular that so profound an observer as Robert Brown should have himself missed the significance of what he saw. The world had to wait for the discovery of protoplasm by Von Mohl till 1846, and till 1850 for its identification with the sarcode of zoologists by Cohn, who is still, I am happy to say, living and at work, and to whom last year the Linnean Society did itself the honour of presenting its medal.

The Edinburgh meeting of the Association, in 1834, was the occasion of the announcement of another memorable discovery of Robert Brown's. I will content myself with quoting Hofmeister's [2] account of it. 'Robert Brown was the discoverer of the polyembrony of the *Coniferæ.* In a later treatise he pointed out the origin of the pro-embryo in large cells of the endosperm, to which he gave the name of corpuscula.' The period of the forties, just half a century ago, looks in the retrospect as one of almost dazzling discovery. To say nothing of the formal appearance of protoplasm on the scene, the foundations were being laid in all directions of our modern botanical morphology. Yet its contemporaries viewed it with a very philosophical calm. Thwaites, who regarded Carpenter as his master, described at the Oxford meeting in 1847 the conjugation of the *Diatomaceæ,* and 'distinctly indicated,' as Carpenter [3] says, 'that conjugation is the primitive phase of sexual reproduction.' Berkeley informed me that the announcement fell perfectly flat. A year or two later Suminski came to London with his splendid discovery (1848) of the archegonia of the fern, the antheridia having been first seen by Nägeli in 1844. Carpenter [4] gave me, many years after, a curious account of its reception. 'At the Council of the Ray Society, at which,' he said, 'I advocated the reproduction of Suminski's book on the "Ferns," I was assured that the close resemblance of the antherozoids to spermatozoa was quite sufficient proof that they could have nothing to do with vegetable reproduction. 'I do not think,' he added—and the complaint is pathetic—'that the men of the present generation, who have been brought up in the *light*, quite apprehend (in this as in other matters) the utter darkness in which we were then groping, or fully recognise the deserts of those who helped them to what they now enjoy.' This was in 1875, and I suppose is not likely to be less true now.

The Oxford Meeting in 1860 was the scene of the memorable debate on the origin of species, at which it is interesting to remember that Henslow presided. On that occasion Section D reached its meridian. The battle was Homeric. However little to the taste of its author, the launching of his great theory was, at any rate, dignified with a not inconsiderable explosion. It may be that it is not given to the men of our day to ruffle the dull level of public placidity with disturbing and far-reaching ideas. But if it were, I doubt whether we have, or need now, the fierce energy which inspired then either the attack or the defence. When we met again in Oxford last year the champion of the old conflict stood in the place of honour, acclaimed of all men, a beautiful and venerable figure. We did not know then that that was to be his farewell.

The battle was not in vain. Six years afterwards, at Nottingham, Sir Joseph

[1] *Proc. Linn. Soc.*, 1887–88, 65.
[2] *Higher Cryptogamia*, 432.
[3] *Memorial Sketch*, 140.
[4] *Loc. cit.*, 141.

Hooker delivered his classical lecture on Insular Floras. It implicitly accepted the new doctrine, and applied it with admirable effect to a field which had long waited for an illuminating principle. The lecture itself has since remained one of the corner-stones of that rational theory of the geographical distribution of plants which may, I think, be claimed fairly as of purely English origin.

Henslow.

Addressing you as I do at Ipswich, there is one name written in the annals of our old Section which I cannot pass over—that of Henslow. He was the Secretary of the Biological Section at its first meeting in 1832, and its President at Bristol in 1836. I suppose there are few men of this century who have indirectly more influenced the current of human thought. For in great measure I think it will not be contested that we owe Darwin to him. As Romanes has told us:[1] 'His letters written to Professor Henslow during his voyage round the world overflow with feelings of affection, veneration, and obligation to his accomplished master and dearest friend—feelings which throughout his life he retained with no diminished intensity. As he used himself to say, before he knew Professor Henslow the only objects he cared for were foxes and partridges.' I do not wish to overstate the facts. The possession of 'the collector's instinct, strong in Darwin from his childhood, as is usually the case in great naturalists,' to use Huxley's[2] words, would have borne its usual fruit in after life, in some shape or other, even if Darwin had not fallen into Henslow's hands. But then the particular train of events which culminated in the great work of his life would never have been started. It appeared to me, then, that it would not be an altogether uninteresting investigation to ascertain something about Henslow himself. The result has been to provide me with several texts, which I think it may be not unprofitable to dwell upon on the present occasion.

In the first place, what was the secret of his influence over Darwin? 'My dear old master in Natural History' ('Life,' ii. 317) he calls him; and to have stood in this relation to Darwin[3] is no small matter. Again, he speaks of his friendship with him as 'a circumstance which influenced my whole career more than any other' (i. 52). The singular beauty of Henslow's character, to which Darwin himself bore noble testimony, would count for something, but it would not in itself be a sufficient explanation. Nor was it that intellectual fascination which often binds pupils to the master's feet; for, as Darwin tells us, 'I do not suppose that anyone would say that he possessed much original genius' (i. 52). The real attraction seems to me to be found in Henslow's possession, in an extraordinary degree, of what may be called the Natural History spirit. This resolves itself into keen observation and a lively interest in the facts observed. 'His strongest taste was to draw conclusions from long-continued minute observations' (i. 52). The old Natural History method, of which it seems to me that Henslow was so striking an embodiment, is now, and I think unhappily, almost a thing of the past. The modern university student of botany puts his elders to blush by his minute knowledge of some small point in vegetable histology. But he can tell you little of the contents of a country hedgerow; and if you put an unfamiliar plant in his hands he is pretty much at a loss how to set about recognising its affinities. Disdaining the field of nature spread at his feet in his own country, he either seeks salvation in a German laboratory or hurries off to the Tropics, convinced that he will at once immortalise himself. But '*cœlum non animum mutat*'; he puts into 'pickle' the same objects as his predecessors, never to be looked at again; or perhaps writes a paper on some obvious phenomena which he could have studied with less fatigue in the Palm House at Kew.

The secret of the right use of travel is the possession of the Natural History instinct, and to those who contemplate it I can only recommend a careful study of Darwin's 'Naturalist's Voyage.' Nothing that came in his way seems to have

[1] *Memorial Notices*, 13. [2] *Proc. R.S.*, xliv. vi.

[3] As I shall have frequent occasion to quote the *Life and Letters*, I shall insert the references in the text.

evaded him or to have seemed too inconsiderable for attention. No doubt some respectable travellers have lost themselves in a maze of observations that have led to nothing. But the example of Darwin, and I might add of Wallace, of Huxley, and of Moseley, show that that result is the fault of the man and not of the method. The right moment comes when the fruitful opportunity arrives to him who can seize it. The first strain of the prelude with which the 'Origin' commences are these words: 'When on board H.M.S. "Beagle" as naturalist, I was much struck with certain facts in the distribution of the organic beings inhabiting South America.' But this sort of vein is not struck at hazard or by him who has not served a tolerably long apprenticeship to the work.

When one reads and re-reads the 'Voyage,' it is simply amazing to see how much could be achieved with a previous training which we now should think ludicrously inadequate. Before Henslow's time the state of the natural sciences at Cambridge was incredible. In fact, Leonard Jenyns,[1] his biographer, speaks of the 'utter disregard paid to Natural History in the University previous to his taking up his residence there.' The Professor of Botany had delivered no lectures for thirty years, and though Sir James Smith, the founder of the Linnean Society, had offered his services, they were declined on the ground of his being a Nonconformist.[2]

As to Henslow's own scientific work, I can but rely on the judgment of those who could appreciate it in relation to its time. According to Berkeley,[3] 'he was certainly one of the first, if not the very first, to see that two forms of fruit might exist in the same fungus.' And this, as we now know, was a fundamental advance in this branch of morphology. Sir Joseph Hooker tells me that his papers were all distinctly in advance of his day. Before occupying the chair of botany, he held for some years that of mineralogy. Probably he owed this to his paper on the Isle of Anglesey, published when he was only twenty-six. I learn from the same authority that this to some extent anticipated, but at any rate strongly influenced, Sedgwick's subsequent work in the same region.

Botanical Teaching.

Henslow's method of teaching deserves study. Darwin says of his lectures 'that he liked them much for their extreme clearness.' 'But,' he adds, 'I did not study botany' (i. 48). Yet we must not take this too seriously. Darwin,[4] when at the Galapagos, 'indiscriminately collected everything in flower on the different islands, and fortunately kept my collections separate.' Fortunately indeed; for it was the results extracted from these collections, when worked up subsequently by Sir Joseph Hooker, which determined the main work of his life. 'It was such cases as that of the Galapagos Archipelago which chiefly led me to study the origin of species' (iii. 159).

Henslow's actual method of teaching went some way to anticipate the practical methods of which we are all so proud. 'He was the first to introduce into the botanical examination for degrees in London the system of practical examination.'[5] But there was a direct simplicity about his class arrangements characteristic of the man. 'A large number of specimens . . . were placed in baskets on a side-table in the lecture-room, with a number of wooden plates and other requisites for dissecting them after a rough fashion, each student providing himself with what he wanted before taking his seat.'[6] I do not doubt that the results were, in their way, as efficient as we obtain now in more stately laboratories.

The most interesting feature about his teaching was not, however, its academic aspect, but the use he made of botany as a general educational instrument. 'He always held that a man of *no* powers of observation was quite an exception.'[7] He thought (and I think he proved) that botany might be used 'for strengthening the observant faculties and expanding the reasoning powers of children in all classes of society.'[8] The difficulty with which those who undertake now to teach our subject have to deal is that most people ask the question, What is the use of

[1] *Memoir*, 175. [2] *Ibid.*, 37. [3] *Ibid.*, 56. [4] *Voyage*, 421.
[5] *Memoir*, 161. [6] *Ibid.*, 39. [7] *Ibid.*, 163. [8] *Ibid.*, 99.

learning botany unless one means to be a botanist? It might indeed be replied that as the vast majority of people never learn anything effectively, they might as well try botany as anything else. But Henslow looked only to the mental discipline; and it was characteristic of the man and of his belief in his methods that when he was summoned to Court to lecture to the Royal family, his lectures 'were, in all respects, identical with those he was in the habit of giving to his little Hitcham scholars';[1] and it must be added that they were not less successful.

This success naturally attracted attention. Botanical teaching in schools was taken up by the Government, and continues to receive support to the present day. But the primitive spirit has, I am afraid, evaporated. The measurement of results by means of examination has been fatal to its survival. The teacher has to keep steadily before his eyes the necessity of earning his grant. The educational problem retires into the background. 'The strengthening of the observant faculties,' and the rest of the Henslowian programme must give way to the imperious necessity of presenting to the examiner candidates equipped with at least the minimum of text-book formulas reproducible on paper. I do not speak in this matter without painful experience. The most astute examiner is defeated by the still more astute crammer. The objective basis of the study on which its whole usefulness is built up is promptly thrown aside. If you supply the apple blossom for actual description, you are as likely as not to be furnished with a detailed account of a buttercup. The training of observation has gone by the board, and the exercise of mere memory has taken its place. But a table of logarithms or a Hebrew grammar would serve this purpose equally well. Yet I do not despair of Henslow's work still bearing fruit. The examination system will collapse from the sheer impossibility of carrying it on beyond a certain point. Freed from its trammels, the teacher will have greater scope for individuality, and the result of his labours will be rewarded after some intelligent system of inspection. And here I may claim support from an unexpected quarter. Mr. Gladstone has recently written to a correspondent:—'I think that the neglect of natural history, in all its multitude of branches, was the grossest defect of our old system of training for the young; and, further, that little or nothing has been done by way of remedy for that defect in the attempts made to alter or reform that system.' I am sure that the importance and weight of this testimony, coming as it does from one whose training and sympathies have always been literary, cannot be denied. That there is already some revival of Henslow's methods, I judge from the fact that I have received applications from Board schools, amounting to some hundreds, for surplus specimens from the Kew museums. Without a special machinery for the purpose I cannot do much, and perhaps it is well. But my staff have willingly done what was possible, and from the letters I have received I gather that the labour has not been wholly misspent.

Museum Arrangement.

This leads me to the last branch of Henslow's scientific work on which I am able to touch, that of the arrangement of museums, especially those which being local have little meaning unless their purpose is strictly educational. I think it is now generally admitted that, both in the larger and narrower aspects of the question, his ideas, which were shared in some measure by Edward Forbes, were not merely far in advance of his time, but were essentially sound. And here I cannot help remarking that the zoologists have perhaps profited more by his teaching than the botanists. I do not know how far Sir William Flower and Professor Lankester would admit the influence of Henslow's ideas. But, so far as my knowledge goes, I am not aware that, at any rate in Europe, there is anything to be seen in public museums comparable to the educational work accomplished by the one at the College of Surgeons and the Natural History Museum, and by the other at Oxford.

I have often thought it singular that in botany we have not kept pace in this matter with our brother naturalists. I do not doubt that vegetable morphology and a vast number of important facts in evolution, as illustrated from the

[1] *Memoir*, 149.

vegetable kingdom, might be presented to the eye in a fascinating way in a carefully arranged museum. The most successful and, indeed, almost the only attempt which has been made in this direction is that at Cambridge, which, I believe, is due to Mr. Gardiner. But our technical methods for preserving specimens still leave much to desire. Something more satisfactory will, it may be hoped, some day be devised, and the whole subject is one which is well worth the careful consideration of our Section. Henslow at least effected a vast improvement in the mode of displaying botanical objects; and a collection prepared by his own hands, which was exhibited at one of the Paris exhibitions, excited the warm admiration of the French botanists, who always appreciate the clear illustration of morphological facts.

Old School of Natural History.

If the old school of natural history of which Henslow in his day was a living spirit is at present, as seems to be the case, continually losing its hold upon us, this has certainly not been due to its want of value as an educational discipline, or to its sterility in contributing new ideas to human knowledge. Darwin's 'Origin of Species' may certainly be regarded as its offspring, and of this Huxley [1] says with justice: 'It is doubtful if any single book, except the "Principia," ever worked so great and rapid a revolution in science, or made so deep an impression on the general mind.' Yet Darwin's biographer, in that admirable Life which ranks with the few really great biographies in our language, remarks (i. 155): 'In reading his books one is reminded of the older naturalists rather than of the modern school of writers. He was a naturalist in the old sense of the word, that is, a man who works at many branches of science, not merely a specialist in one.' This is no doubt true, but does not exactly hit off the distinction between the kind of study which has gone out of fashion and that which has come in. The older workers in biology were occupied mainly with the external or, at any rate, grosser features of organisms and their relation to surrounding conditions; the modern, on the other hand, are engaged on the study of internal and intimate structure. Work in the laboratory, with its necessary limitations, takes the place of research in the field. One may almost, in fact, say that the use of the compound microscope divides the two classes. Asa Gray has compared Robert Brown with Darwin as the 'two British naturalists' who have, 'more than any others, impressed their influence upon science in the nineteenth century.' [2] Now it is noteworthy that Robert Brown did all his work with a simple microscope. And Francis Darwin writes of his father: 'It strikes us nowadays as extraordinary that he should have had no compound microscope when he went his "Beagle" voyage; but in this he followed the advice of Robert Brown, who was an authority on such matters' (i. 145). One often meets with persons, and sometimes of no small eminence, who speak as if there were some necessary antagonism between the old and the new studies. Thus I have heard a distinguished systematist describe the microscope as a curse, and a no less distinguished morphologist speak of a herbarium having its proper place on a bonfire. To me I confess this anathematisation of the instruments of research proper to any branch of our subject is not easily intelligible. Yet in the case of Darwin himself it is certain that if his earlier work may be said to rest solely on the older methods, his later researches take their place with the work of the new school. At our last meeting Pfeffer vindicated one of his latest and most important observations.

The case of Robert Brown is even more striking. He is equally great whether we class him with the older or the modern school. In fact, so far as botany in this country is concerned, he may be regarded as the founder of the latter. It is to him that we owe the establishment of the structure of the ovule and its development into the seed. Even more important were the discoveries to which I have already referred, which ultimately led to the establishment of the group of Gymnosperms. 'No more important discovery,' says Sachs,[3] 'was ever made in the domain of comparative morphology and systematic botany. The first steps towards this result, which was clearly brought out by Hofmeister twenty-five years later,

[1] *Proc. R.S.*, xliv. xvii. [2] *Nature*, x. 80. [3] *History*, 142.

were secured by Robert Brown's researches, and he was incidentally led to these researches by some difficulties in the construction of the seed of an Australian genus.' Yet it may be remembered that he began his career as naturalist to Flinders's expedition for the exploration of Australia. He returned to England with 4,000 'for the most part new species of plants.' And these have formed the foundation of our knowledge of the flora of that continent. Brown's chief work was done between 1820 and 1840, and, as Sachs[1] tells us, 'was better appreciated during that time in Germany than in any other country.'

Modern School.

The real founder of the modern teaching in this country in both branches of biology I cannot doubt was Carpenter. The first edition of his admirable 'Principles of Comparative Physiology' was published in 1838, the last in 1854. All who owe, as I do, a deep debt of gratitude to that book will agree with Huxley[2] in regarding it as 'by far the best general survey of the whole field of life and of the broad principles of biology which had been produced up to the time of its publication. Indeed,' he adds, 'although the fourth edition is now in many respects out of date, I do not know its equal for breadth of view, sobriety of speculation, and accuracy of detail.'

The charm of a wide and philosophic survey of the different forms under which life presents itself could not but attract the attention of teachers. Rolleston elaborated a course of instruction in zoology at Oxford in which the structures described in the lecture-room were subsequently worked out in the laboratory. In 1872 Huxley organised the memorable course in elementary biology at South Kensington which has since, in its essential features, been adopted throughout the country. In the following year, during Huxley's absence abroad through ill-health, I arranged, at his request, a course of instruction on the same lines for the Vegetable Kingdom.

That the development of the new teaching was inevitable can hardly be doubted, and I for my part am not disposed to regret the share I took in it. But it was not obvious, and certainly it was not expected, that it would to so large an extent cut the ground from under the feet of the old Natural History studies. The consequences are rather serious, and I think it is worth while pointing them out.

In a vast empire like our own there is a good deal of work to be done and a good many posts to be filled, for which the old Natural History training was not merely a useful but even a necessary preparation. But at the present time the universities almost entirely fail to supply men suited to the work. They neither care to collect, nor have they the skilled aptitude for observation. Then, though this country is possessed at home of incomparable stores of accumulated material, the class of competent amateurs who were mostly trained at our universities and who did such good service in working that material out is fast disappearing. It may not be easy indeed in the future to fill important posts even in this country with men possessing the necessary qualifications. But there was still another source of naturalists, even more useful, which has practically dried up. It is an interesting fact that the large majority of men of the last generation who have won distinction in this field have begun their career with the study of medicine. That the kind of training that Natural History studies give is of advantage to students of medicine which, rightly regarded, is itself a Natural History study, can hardly be denied. But the exigencies of the medical curriculum have crowded them out, and this, I am afraid, must be accepted as irremediable. I cannot refrain from reading you, on this point, an extract from a letter which I have received from a distinguished official lately entrusted with an important foreign mission. I should add that he had himself been trained in the old way.

'I have had my time, and must leave to younger men the delight of working these interesting fields. Such chances never will occur again, for roads are now being made and ways cut in the jungle and forest, and you have at hand all sorts of trees level on the ground ready for study. These bring down with them orchids, ferns, and climbers of many kinds, including rattan palms, &c. But, excellent as are the officers who devote their energy to thus opening up this country, there is not one

[1] *Loc. cit.*, 139, 140. [2] *Memorial Sketch*, 67.

man who knows a palm from a dragon-tree, so the chance is lost. Strange to say, the medical men of the Government service know less and care less for Natural History than the military men, who at least regret they have no training or study to enable them to take an intelligent interest in what they see around them. A doctor nowadays cares for no living thing larger or more complicated than a *bacterium* or a *bacillus*.'

But there are other and even more serious grounds why the present dominance of one aspect of our subject is a matter for regret. In the concluding chapter of the 'Origin,' Darwin wrote: 'I look with confidence to the future—to young and rising naturalists.' But I observe that most of the new writers on the Darwinian theory, and, oddly enough, especially when they have been trained at Cambridge, generally begin by more or less rejecting it as a theory of the origin of species, and then proceed unhesitatingly to reconstruct it. The attempt rarely seems to me successful, perhaps because the limits of the laboratory are unfavourable to the accumulation of the class of observations which are suitable for the purpose. The laboratory, in fact, has not contributed much to the Darwinian theory, except the 'Law of Recapitulation,' and that, I am told, is going out of fashion.

The Darwinian theory, being, as I have attempted to show, the outcome of the Natural History method, rested at every point on a copious basis of fact and observation. This more modern speculation lacks. The result is a revival of transcendentalism. Of this we have had a copious crop in this country, but it is quite put in the shade by that with which we have been supplied from America. Perhaps the most remarkable feature is the persistent vitality of Lamarckism. As Darwin remarks: 'Lamarck's one suggestion as to the cause of the gradual modification of species—effort excited by change of conditions—was, on the face of it, inapplicable to the whole vegetable world' (ii. 189). And if we fall back on the inherited direct effect of change of conditions, though Darwin admits that 'physical conditions have a more direct effect on plants than on animals' (ii. 319), I have never been able to convince myself that that effect is inherited. I will give one illustration. The difference in habit of even the same species of plant when grown under mountain and lowland conditions is a matter of general observation. It would be difficult to imagine a case of 'acquired characters' more likely to be 'inherited.' But this does not seem to be the case. The recent careful research of Gaston Bonnier only confirms the experience of cultivators. 'The modifications acquired by the plant when transported for a definite time from the plains to the Alps, or *vice versâ*, disappear at the end of the same period when the plant is restored to its original conditions.'[1]

Darwin, in an eloquent passage, which is too long for me to quote,[2] has shown how enormously the interest of Natural History is enhanced 'when we regard every production of Nature as one which has had a long history,' and 'when we contemplate every complex structure . . . as the summing up of many contrivances.' But this can only be done, or at any rate begun, in the field and not in the laboratory.

A more serious peril is the dying out amongst us of two branches of botanical study in which we have hitherto occupied a position of no small distinction. Apart from the staffs of our official institutions, there seems to be no one who either takes any interest in, or appreciates in the smallest degree, the importance of systematic and descriptive botany. And geographical distribution is almost in a worse plight, yet Darwin calls it, 'that grand subject, that almost keystone of the laws of creation' (i. 356).

I am aware that it is far easier to point out an evil than to remedy it. The teaching of botany at the present day has reached a pitch of excellence and earnestness which it has never reached before. That it is somewhat one-sided cannot probably be remedied without a subdivision of the subject and an increase in the number of teachers. If it has a positive fault, it is that it is sometimes inclined to be too dogmatic and deductive. Like Darwin, at any rate in a biological matter, 'I never feel convinced by deduction, even in the case of

[1] *Ann. d. Sc. nat.*, 7e sér. xx. 355. [2] *Origin*, 426.

H. Spencer's writings' (iii. 168). The intellectual indolence of the student inclines him only too gladly to explain phenomena by referring them to 'isms,' instead of making them tell their own story.

ORGANISATION OF SECTION.

I am afraid I have detained you too long over these matters, on which I must admit I have spoken with some frankness. But I take it that one of the objects of our Section is to deliver our minds of any perilous stuff that is fermenting in it. But now, having taken leave of the past, let us turn to the future.

We start at least with a clean slate. We cannot bind our successors, it is true, at other meetings. But I cannot doubt that it will be in our power to materially shape our future, notwithstanding. When we were only a department I think we all felt the advantage of these annual meetings, of the profitable discussion formal and informal, and of the privilege of meeting so many of our foreign brethren who have so generously supported us by their presence and sympathy.

I am anxious, then, to suggest that we should conduct our proceedings on as broad lines as possible. I do not think we should be too ready to encourage papers which may well be communicated to societies, either local or central.

The field is large; the labourers as they advance in life can hardly expect to keep pace with all that is going on in it. We must look to individual members of our number to help us by informing and stimulating addresses on subjects they have made peculiarly their own, or on important researches on which they have been especially engaged.

NOMENCLATURE.

There is one subject upon which, from my official position elsewhere, I desire to take the opportunity of saying a few words. It is that of Nomenclature. It is not on its technical side, I am afraid, of sufficient general interest to justify my devoting to it the space which its importance would otherwise deserve. But I hope to be able to enlist your support for the broad common-sense principles on which our practice should rest.

As I suppose, everyone knows we owe our present method of nomenclature in natural history to Linnæus. He devised the binominal, or, as it is often absurdly called, the binomial system. That we must have a technical system of nomenclature I suppose no one here will dispute. It is not, however, always admitted by popular writers who have not appreciated the difficulty of the matter, and who think all names should be in the vernacular. There is the obvious difficulty that the vast majority of plants do not possess any names at all, and the attempts to manufacture them in a popular shape have met with but little success. Then, from lack of discriminating power on the part of those who use them, vernacular names are often ambiguous; thus Bullrush is applied equally to *Typha* and to *Scirpus,* plants extremely different. Vernacular names, again, are only of local utility, while the Linnean system is intelligible throughout the world.

A technical name, then, for a plant or animal is a necessity, as without it we cannot fix the object of our investigations into its affinity, structure, or properties.[1] 'Nomina si nescis perit et cognitio rerum.'

In order to get clear ideas on the matter let us look at the logical principles on which such names are based. It is fortunate for us that these are stated by Mill, who, besides being an authority on logic, was also an accomplished botanist. He tells us:[2] 'A naturalist, for purposes connected with his particular science, sees reason to distribute the animal or vegetable creation into certain groups rather than into any others, and he requires a name to bind, as it were, each of his groups together.' He further explains that such names, whether of species, genera, or orders, are what logicians call connotative: they *denote* the members of each group, and *connote* the distinctive characters by which it is defined. A species, then, connotes the common characters of the individuals belonging to it; a genus, those of the species; an order, those of the genera.

[1] *Linn. Phil.*, 210. [2] *System of Logic,* i. 132.

But these are the logical principles, which are applicable to names generally. A name such as *Ranunculus repens* does not differ in any particular from a name such as John Smith, except that one denotes a species, the other an individual.

This being the case, and technical names being a necessity, they continually pass into general use in connection with horticulture, commerce, medicine, and the arts. It seems obvious that, if science is to keep in touch with human affairs, stability in nomenclature is a thing not merely to aim at but to respect. Changes become necessary, but should never be insisted on without grave and solid reason. In some cases they are inevitable unless the taxonomic side of botany is to remain at a standstill. From time to time the revision of a large group has to be undertaken from a uniform and comparative point of view. It then often occurs that new genera are seen to have been too hastily founded on insufficient grounds, and must therefore be merged in others. This may involve the creation of a large number of new names, the old ones becoming henceforth a burden to literature as synonyms. It is usual in such cases to retain the specific portion of the original name, if possible. If it is, however, already preoccupied in the genus to which the transference is made, a new one must be devised. Many modern systematists have, however, set up the doctrine that a specific epithet once given is indelible, and whatever the taxonomic wanderings of the organism to which it was once assigned, it must always accompany it. This, however, would not have met with much sympathy from Linnæus, who attached no importance to the specific epithet at all: 'Nomen specificum sine generico est quasi pistillum sine campana.'[1] Linnæus always had a solid reason for everything he did or said, and it is worth while considering in this case what it was.

Before his time the practice of associating plants in genera had made some progress in the hands of Tournefort and others, but specific names were still cumbrous and practically unusable. Genera were often distinguished by a single word; and it was the great reform accomplished by Linnæus to adopt the binominal principle for species. But there is this difference. Generic names are unique, and must not be applied to more than one distinct group. Specific names might have been constituted on the same basis; the specific name in that case would then have never been used to designate more than one plant, and would have been sufficient to indicate it. We should have lost, it is true, the useful information which we get from our present practice in learning the genus to which the species belongs; but theoretically a nomenclature could have been established on the one-name principle. The thing, however, is impossible now, even if it were desirable. A specific epithet like *vulgaris* may belong to hundreds of different species belonging to as many different genera, and taken alone is meaningless. A Linnean name, then, though it consists of two parts, must be treated as a whole. 'Nomen omne plantarum constabit nomine generico et specifico.'[2] A fragment can have no vitality of its own. Consequently, if superseded, it may be replaced by another which may be perfectly independent.[3]

It constantly happens that the same species is named and described by more than one writer, or different views are taken of specific differences by various writers; the species of one are therefore 'lumped' by another. In such cases, where there is a choice of names, it is customary to select the earliest published. I agree, however, with the late Sereno Watson[4] that 'there is nothing whatever of an ethical character inherent in a name, through any priority of publication or position, which should render it morally obligatory upon anyone to accept one name rather than another.' And in point of fact Linnæus and the early systematists attached little importance to priority. The rigid application of the principle involves the assumption that all persons who describe or attempt to describe plants

[1] *Phil.*, 21 [2] *Phil.*, 212.

[3] As Alphonse de Candolle points out in a letter published in the *Bull. de la Soc. bot. de France* (xxxix.), 'the real merit of Linnæus has been to combine, for all plants, the generic name with the specific epithet.' It is important to remember that in a logical sense the 'name' of a species consists, as Linnæus himself insisted, in the combination, not in the specific epithet, which is a mere fragment of the name, and meaningless when taken by itself.

[4] *Nature*, xlvii. 54.

are equally competent to the task. But this is so far from being the case that it is sometimes all but impossible even to guess what could possibly have been meant.[1]

In 1872 Sir Joseph Hooker[2] wrote: 'The number of species described by authors who cannot determine their affinities increases annually, and I regard the naturalist who puts a described plant into its proper position in regard to its allies as rendering a greater service to science than its describer when he either puts it into a wrong place or throws it into any of those chaotic heaps, miscalled genera, with which systematic works still abound.' This has always seemed to me not merely sound sense, but a scientific way of treating the matter. What we want in nomenclature is the maximum amount of stability and the minimum amount of change compatible with progress in perfecting our taxonomic system. Nomenclature is a means, not an end. There are perhaps 150,000 species of flowering plants in existence. What we want to do is to push on the task of getting them named and described in an intelligible manner, and their affinities determined as correctly as possible. We shall then have material for dealing with the larger problems which the vegetation of our globe will present when treated as a whole. To me the botanists who waste their time over priority are like boys who, when sent on an errand, spend their time in playing by the roadside. By such men even Linnæus is not to be allowed to decide his own names. To one of the most splendid ornaments of our gardens he gave the name of *Magnolia grandiflora*: this is now to be known as *Magnolia fœtida*. The reformer himself is constrained to admit, 'The change is a most unfortunate one in every way.'[3] It is difficult to see what is gained by making it, except to render systematic botany ridiculous. The genus *Aspidium*, known to every fern-cultivator, was founded by Swartz. It now contains some 400 species, of which the vast majority were of course unknown to him at the time; yet the names of all these are to be changed because Adanson founded a genus, *Dryopteris*, which seems to be the same thing as *Aspidium*. What, it may be asked, is gained by the change? To science it is certainly nothing. On the other hand, we lumber our books with a mass of synonyms, and perplex everyone who takes an interest in ferns. It appears that the name of the well-known Australian genus *Banksia* really belongs to *Pimelea*; the species are therefore to be renamed, and *Banksia* is to be rechristened *Sirmuellera*, after Sir Ferdinand von Mueller; a proposal which, I need hardly say, did not emanate from an Englishman.

I will not multiply instances. But the worst of it is that those who have carefully studied the subject know that, from various causes which I cannot afford the time to discuss, when once it is attempted to disturb accepted nomenclature, it is almost impossible to reach finality. Many genera only exist by virtue of their redefinition in modern times; in the form in which they were originally promulgated they have hardly any intelligible meaning at all.

It can hardly be doubted that one cause of the want of attention which systematic botany now receives is the repulsive labour of the bibliographical work with which it has been overlaid. What an enormous bulk nomenclature has already attained may be judged from the *Index Kewensis*, which was prepared at Kew, and which we owe to the munificence of Mr. Darwin. In his own studies he constantly came on the track of names which he was unable to run down to their source. This the *Index* enables to be done. It is based, in fact, on a manuscript index which we compiled for our own use at Kew. But it is a mistake to suppose that it is anything more than the name signifies, or that it expresses any opinion as to the validity of the names themselves. That those who use the book must judge of for themselves. We have indexed existing names, but we have not added to the burden by making any new ones for species already described.

What synonymy has now come to may be judged by an example supplied me by my friend Mr. C. B. Clarke. For a single species of *Fimbristylis* he finds 135

[1] Darwin, who always seems to me, almost instinctively, to take the right view in matters relating to natural history, is (*Life*, vol. i. p. 364) dead against the new 'practice of naturalists appending for perpetuity the name of the *first* describer to species.' He is equally against the priority craze:—'I cannot yet bring myself to reject very *well-known* names' (*ibid.*, p. 369).

[2] *Flora of British India*, i. vii.

[3] *Garden and Forest*, ii. 615.

published names under six genera. If we go on in this way we shall have to invent a new Linnæus, wipe out the past, and begin all over again.

Although I have brought the matter before the Section, it is not one in which this, or indeed any collective assembly of botanists, can do very much. While I hope I shall carry your assent with the general principles I have laid down, it must be admitted that the technical details can only be appreciated by experienced specialists. All that can be hoped is a general agreement amongst the staffs of the principal institutions in different countries where systematic botany is worked at; the free-lances must be left to do as they like.

Publications.

I have dwelt at such length on certain aspects of my subject that perhaps, without great injustice, you may retort on me the complaint of one-sidedness. But when I survey the larger field of botany in this country, the prospect seems to me so vast that I should despair even if I had my whole address at my disposal of doing it justice. I think that its extent is measured by the way in which the publications belonging to our subject are maintained. First of all, we have access to the Royal Society, a privilege of which I hope we shall always continue to take advantage for communications which either treat of fundamental subjects, or at least are of general interest to biologists. Next to this we have our ancient Linnean Society, with a branch of its publications handsomely and efficiently devoted to systematic work. Then we have the 'Annals of Botany,' which has now, I think, established its position, and which brings together the chief morphological and physiological work accomplished in the country. Lastly, we have the 'Journal of Botany,' a less ambitious but useful periodical, which is mainly devoted to the labours of British botanists. I remember there was a time when I thought that this, at any rate, was an exhausted field. But it is not so; knowledge in its most limited aspects is inexhaustible if the labourer have the necessary insight. The discoveries of Mr. Arthur Bennett amongst the potamogetons of the Eastern Counties is a striking and brilliant instance.

Besides the publication of the 'Annals' we owe to the Oxford Press a splendid series of the best foreign text-books issued in our own language. If the thought has sometimes occurred to one's mind that we were borrowers too freely from our indefatigable neighbours, I, at least, remember that the late Professor Eichler paid us the compliment of saying that he preferred to read one of these monumental books in the English translation rather than in the original. I believe it is no secret that botany owes the aid that Oxford has rendered it in these and other matters in great measure to my old friend the Master of Pembroke College, than whom I believe science has no more devoted supporter.

Palæobotany.

I have said much of recent botany; I must not pass over that of past ages. Two notable workers in this field have passed away since our last meeting. Saporta was with us at Manchester, and we shall not readily forget his personal charm. If some of his work has about it a too imaginative character, the patience and entire sincerity with which he traced the origin of the existing forms of vegetation in Southern Europe to their ancestors in the not distant geological past will always deserve attentive study. But in the venerable, yet always youthful, Williamson we lose a figure whose memory we shall long preserve. With rare instinct he accumulated a wealth of material illustrative of the vegetation of the Carboniferous epoch, which, I suppose, is unique in the world. And this was prepared for examination with incomparable patience either by his own hands or under his own eyes. He illustrated it with absolute fidelity. And if he did not in describing it always use language with which we could agree, nothing could ruffle either his imperturbable good nature or the noble simplicity of his character. Truth to tell, we were often in friendly warfare with him. But I rejoice to think that before his peaceful end came he had patiently reconsidered and abandoned all that we regarded as his heresies, but which were, in truth, only the old manner of looking at things. And I think that if anything could have contributed to make his departure happy, it was the conviction that the completion of his work and his scientific reputation would remain perfectly secure in the hands of Dr. Scott.

Vegetable Physiology.

Turning again to the present, the difficulty is to limit the choice of topics on which I would willingly dwell. In an address which I delivered at the Bath meeting in 1888 I ventured to point out the important part which the action of enzymes would be found to play in plant metabolism. My expectations have been more than realised by the admirable work of Professor Green on the one hand, and of Mr. Horace Brown on the other. The wildest imagination could not have foreseen the developments which in the hands of animal physiologists would spring from the study of the fermentative changes produced by yeast and bacteria. These, it seems to me, bid fair to revolutionise our whole conceptions of disease. The reciprocal action of ferments, developed in so admirable a manner by Marshall Ward in the case of the ginger-beer plant, is destined, I am convinced, to an expansion scarcely less important.

But, perhaps, the most noteworthy feature in recent work is the disposition to reopen in every direction fundamental questions. And here, I think, we may take a useful lesson from the practice of the older Sections, and adopt the plan of entrusting the investigation of special problems to small committees, or to individuals who are willing to undertake the labour of reporting upon special questions which they have made peculiarly their own. These reports would be printed *in extenso,* and are capable of rendering invaluable service by making accessible acquired knowledge which could not be got at in any other way.

We owe to Mr. Blackman a masterly demonstration of the fact, long believed, but never, perhaps, properly proved, that the surface of plants is ordinarily impermeable to gases. Mr. Dixon has brought forward some new views about water-movement in plants, which I confess I found less instructive than many of my brother botanists. They are expressed in language of extreme technicality; but, as far as I understand them, they amount to this. The water moving in the plant is contained in capillary channels; as it evaporates at the surface of the leaves a tensile strain is set up, as long as the columns are not broken, to restore the original level. I can understand that in this way the 'transpiration current' may be maintained. But what I want to know is how this explains the phenomena in the sugar maple, a single tree of which will yield, I believe, 20–30 gallons of fluid before a single leaf is expanded.

We owe to Messrs. Darwin and Acton the supply of a 'Manual of Practical Vegetable Physiology,' the want of which has long been keenly felt. Like the father of one of the authors, 'I love to exalt plants' (i. 98). I have long been satisfied that the facts of vegetable physiology are capable of being widely taught, and are not less significant and infinitely more convenient than most of those which can be easily demonstrated on the animal side. How little any accurate knowledge of the subject has extended was conspicuously demonstrated in a recent discussion at the Royal Society, when two of our foremost chemists roundly denied the existence of a function of respiration in plants, because it was unknown to Liebig!

Assimilation.

The greatest and most fundamental problem of all is that of assimilation. The very existence of life upon the earth ultimately depends upon it. The veil is slowly, but I think surely, being lifted from its secrets. We now know that starch, if its first visible product, is not its first result. We are pretty well agreed that this is what I have called a 'proto-carbohydrate.' How is the synthesis of this effected? Mr. Acton, whose untimely end we cannot but deeply deplore, made some remarkable researches, which were communicated to the Royal Society in 1889, on the extent to which plants could take advantage of organic compounds made, so to speak, ready to their hand. Loew, in a remarkable paper, which will perhaps attract less attention than it deserves from being published in Japan,[1] has,

[1] *Bull. College of Agric. Imp. Univ. Tokio,* vol. ii.

from the study of the nutrition of bacteria, arrived at some general conclusions in the same direction. Bokorny appears recently to have similarly experimented on algæ. Neither writer, however, seems to have been acquainted with Acton's work. The general conclusion which I draw from Loew is to strengthen the belief that form-aldehyde is actually one of the first steps of organic synthesis, as long ago suggested by Adolph Baeyer. Plants, then, will avail themselves of ready-made organic compounds which will yield them this body. That a sugar can be constructed from it has long been known, and Bokorny has shown that this can be utilised by plants in the production of starch.

The precise mode of the formation of form-aldehyde in the process of assimilation is a matter of dispute. But it is quite clear that either the carbon dioxide or the water, which are the materials from which it is formed, must suffer dissociation. And this requires a supply of energy to accomplish it. Warington has drawn attention to the striking fact that in the case of the nitrifying bacterium, assimilation may go on without the intervention of chlorophyll, the energy being supplied by the oxidation of ammonia. This brings us down to the fact, which has long been suspected, that protoplasm is at the bottom of the whole business, and that chlorophyll only plays some subsidiary and indirect part, perhaps, as Adolph Baeyer long ago suggested, of temporarily fixing carbon oxide like hæmoglobin, and so facilitating the dissociation.

Chlorophyll itself is still the subject of the careful study by Dr. Schunck, originally commenced by him some years ago at Kew. This will, I hope, give us eventually an accurate insight into the chemical constitution of this important substance.

The steps in plant metabolism which follow the synthesis of the proto-carbohydrate are still obscure. Brown and Morris have arrived at the unexpected conclusion that 'cane-sugar is the first sugar to be synthesised by the assimilatory processes.' I made some remarks upon this at the time,[1] which I may be permitted to reproduce here.

'The point of view arrived at by botanists was briefly stated by Sachs in the case of the sugar-beet, starch in the leaf, glucose in the petiole, cane-sugar in the root. The facts in the sugar-cane seem to be strictly comparable.[2] Cane-sugar the botanist looks on, therefore, as a "reserve material." We may call "glucose" the sugar "currency" of the plant, cane-sugar its "banking reserve."

'The immediate result of the diastatic transformation of starch is not glucose, but maltose. But Mr. Horace Brown has shown in his remarkable experiments on feeding barley embryos that, while they can readily convert maltose into cane-sugar, they altogether fail to do this with glucose. We may conclude, therefore, that glucose is, from the point of view of vegetable nutrition, a somewhat inert body. On the other hand, evidence is apparently wanting that maltose plays the part in vegetable metabolism that might be expected of it. Its conversion into glucose may be perhaps accounted for by the constant presence in plant tissues of vegetable acids. But, so far, the change would seem to be positively disadvantageous. Perhaps glucose, in the botanical sense, will prove to have a not very exact chemical connotation.

'That the connection between cane-sugar and starch is intimate is a conclusion to which both the chemical and the botanical evidence seems to point. And on botanical grounds this would seem to be equally true of its connection with cellulose.

'It must be confessed that the conclusion that "cane-sugar" is the first sugar to be synthesised by the assimilatory processes seems hard to reconcile with its probable high chemical complexity, and with the fact that, botanically, it seems to stand at the end and not at the beginning of the series of metabolic change.'

Protoplasmic Chemistry.

The synthesis of proteids is the problem which is second only in importance to that of carbohydrates. Loew's views of this deserve attentive study. Asparagin, as has long been suspected, plays an important part. It has, he says, two sources

[1] *Journ. Chem. Soc.*, 1893, 673. [2] *Kew Bulletin*, 1891, 35–41.

in the plant. 'It may either be formed directly from glucose, ammonia (or nitrates) and sulphates, or it may be a transitory product between protein-decomposition and reconstruction from the fragments.'[1]

In the remarks I made to the Chemical Society I ventured to express my conviction that the chemical processes which took place under the influence of protoplasm were probably of a different kind from those with which the chemist is ordinarily occupied. The plant produces a profusion of substances, apparently with great facility, which the chemist can only build up in the most circuitous way. As Victor Meyer[2] has remarked: 'In order to isolate an organic substance we are generally confined to the purely accidental properties of crystallisation and volatilisation.' In other words, the chemist only deals with bodies of great molecular stability; while it cannot be doubted that those which play a part in the processes of life are the very opposite in every respect. I am convinced that if the chemist is to help in the field of protoplasmic activity, he will have to transcend his present limitations, and be prepared to admit that as there may be more than one algebra, there may be more than one chemistry. I am glad to see that a somewhat similar idea has been suggested by other fields of inquiry. Professor Meldola[3] thinks that the investigation of photochemical processes 'may lead to the recognition of a new order of chemical attraction, or of the old chemical attraction in a different degree.' I am delighted to see that the ideas which were floating, I confess, in a very nebulous form in my brain are being clothed with greater precision by Loew.

In the paper which I have already quoted, he says of proteids:[4] 'They are *exceedingly labil compounds* that can be easily converted into relatively stable ones. A great lability is the indispensable and necessary foundation for the production of the various actions of the living protoplasm, for the mode of motions that move the life-machinery. There is a *source of motion* in the labil position of atoms in molecules, a source that has hitherto not been taken into consideration either by chemists or by physicists.'

But I must say no more. The problems to which I might invite attention on an occasion like this are endless. I have not even attempted to do justice to the work that has been accomplished amongst ourselves, full of interest and novelty as it is. But I will venture to say this, that if capacity and earnestness afford an augury of success, the prospects of the future of our Section possess every element of promise.

The following Papers were read:—

1. *On a False* Bacterium. *By* Professor MARSHALL WARD, *F.R.S.*

The author has isolated from the Thames a form which gives all the ordinary reactions of a bacterium in plate-cultures and tube-cultures in gelatine, agar, potato, broth, milk, &c.

It is a rod-like form, 1 μ thick, and up to 2–4 μ long, stains like a bacillus, and cannot be distinguished from a true Schizomycete by the methods in common use.

On cultivating it under high powers—one-twelfth and one-twentieth oil immersions—from the single cell, however, it is found to form small, shortly branched mycelia the growth and segmentation of which are acropetal. This turns out to be a minute oidial form of a true fungus.

Its true nature can only be ascertained by the isolation and culture through all stages from the single cell, according to the original methods of gelatine cultures of Klebs, Brefeld, and De Bary which preceded and suggested the methods employed by bacteriologists; and the facts discovered raise interesting questions as to the character of alleged 'branching' bacteria on the one hand, and the multiple derivation of the heterogeneous group of micro-organisms, termed bacteria in general on the other.

[1] *Loc. cit.*, 64.
[2] *Pharm. Journ.*, 1890, 773.
[3] *Nature*, xlii. 250
[4] *Loc. cit.*, 13.

2. *On the Archesporium.* *By* Professor F. O. Bower, *F.R.S.*

Professor Bower pointed out that the recognition of the archesporium as consistently of hypodermal origin cannot be upheld, and quoted as exceptions *Equisetum, Isoetes, Ophioglossum,* and especially the leptosporangiate ferns. He laid down the general principle that the sporangia, as regards their development, should be studied in the light of a knowledge of the apical meristems of the plants in question. Where the apical meristems are stratified, the archesporium is hypodermal in the usual sense; where initial cells occur, the archesporium is derived by periclinal divisions of superficial cells. Intermediate types of meristem show an intermediate type of origin of the archesporium: He cited as an illustrative case that of *Ophioglossum,* admitting that the hypodermal band of potential archesporium, which he had previously described, does not occur always or in all species. But so far from thus giving up the case for a comparison with *Lycopodium,* he holds that as *Ophioglossum* has a single initial cell in stem and root, it would be contrary to experience to expect or demand a hypodermal archesporium.

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3. *Note on the Occurrence in New Zealand of two forms of Peltoid*[1] *Trentepohliaceæ, and their relation to the Lichen* Strigula. *By* A. Vaughan Jennings, *F.L.S., F.G.S.*

The Trentepohliaceæ which form epiphyllous cell-plates are at present known only from the tropics (with the exception of two imperfectly developed forms in the northern temperate zone). They have been recorded from S. America (Bornet), India and Ceylon (the *Mycoidea parasitica* of Cunningham and Marshall Ward), and the East Indies (Karsten), but not up to the present time from New Zealand.

The present paper gives a summary of previous literature, and describes two forms found by the writer in New Zealand.

(1) *Phycopeltis expansa* (new species).—This species forms wide-spreading yellow cell-plates on the leaves of Nesodaphne in the North Island (Rotorua), and in the South Island (near Picton). Sporangia of two kinds: (*a*) enlarged cells of the disc; (*b*) borne singly on a hooked pedicel supported on a single basal cell. The plant is often associated with brown fungus hyphæ growing between the cell-rows, but not affecting the growth of the alga. On the other hand, when attacked by different hyphæ, the result is the formation of the lichen *Strigula,* which in Ceylon was shown by Ward to have for its algal element the *Mycoidea parasitica,* Cunn.

(2) *Phycopeltis nigra* (new species).—The second form is found also on leaves of *Nesodaphne* with the *Phycopeltis* above described, and alone on fronds of *Asplenium falcatum.* Sporangia in the disc are present, but no trace of sporangia on pedicels is observed.

The plant always forms narrow, radiating, and branching bands, never circular discs: the margins often irregular and tending to break into filaments.

There are two distinct varieties:—(*a*) a comparatively large-celled form with barren hairs well developed; (*b*) a small-celled type entirely devoid of hairs.

The most remarkable feature, however, is the *colour.* On the leaf the plant appears perfectly black, and by transmitted light has the olive-green colour characteristic of many fungi, quite different from any of the ordinary Trentepohlias. The plant is never attacked by fungus hyphæ, and never takes any part in lichen formation, even when on the same leaf with *Phycopeltis expansa* and the associated *Strigula.*

[1] Term used for those which form cell-plates (type Phycopeltis), as distinguished from cell-filaments (Trentepohlia).

FRIDAY, SEPTEMBER 13.

The following Papers were read :—

1. *Experimental Studies in the Variation of Yeast Cells. By* Dr. EMIL CHR. HANSEN, *Copenhagen.*

The author gave an account of his earlier and more recent investigations. Among the latter he especially dwelt on those in which, by one treatment, varieties were produced that gave more, and by another treatment less, alcohol than their parent cells. He pointed out that the observed variations could be grouped under certain rules. From his researches on the agencies and causes to which variation is due, he found that temperature was the most influential external factor.[1]

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2. *On a New Form of Fructification in* Sphenophyllum. *By* Graf SOLMS-LAUBACH, *Strassburg.*

Graf Solms gave a brief sketch of the history of our knowledge of the fructification of the Carboniferous genus *Sphenophyllum.* He described the type of strobilus originally named by Williamson *Volkmannia Dawsoni,* and subsequently placed by Weiss in the genus *Bowmanites;* this fructification has recently been shown by Williamson and Zeiller to belong to *Sphenophyllum.* The author proceeded to give an account of a new form of strobilus recently obtained from rocks of Culm age in Silesia; this shows certain important deviations from the fructifications previously examined. In the *Sphenophyllum* strobili from the Coal-measures the axis bears successive verticils of coherent bracts, the sporangia are borne singly at the end of long pedicils twice as numerous as the bracts, and arising from the upper surface of the coherent disc near the axil. In the Culm species, *Sphenophyllum Römeri,* sp. nov., the bracts of successive whorls are superposed and not alternate, as described by other writers, in the Coal-measure species; a more important feature of the new form is the occurrence of two sporangia instead of one in each sporangiophore or pedicil.

Graf Solms referred to the unique collection of microscopic preparations of fossil plants left by Professor Williamson; he emphasised in the strongest terms the immense importance of the collection, and pointed out how every worker in the field of Palæozoic botany must constantly consult the invaluable type specimens in the Williamson cabinets.

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3. *The Chief Results of Williamson's Work on the Carboniferous Plants. By* Dr. D. H. SCOTT, *F.R.S.*

The origin and history of the late Professor Williamson's researches on the Carboniferous flora were briefly traced. His great work, chiefly, though not entirely, contained in his long series of memoirs in the 'Philosophical Transactions' of the Royal Society, consisted in thoroughly elucidating the structure of British fossil plants of the coal period, and thus determining, on a sound basis, the main lines of their affinities.

Four of the principal types investigated by Williamson were selected for illustration—the *Calamarieæ,* the *Sphenophylleæ,* the *Lyginodendreæ,* and the *Lycopodiaceæ.*

(1) The *Calamarieæ.*—Williamson's great aim, which he kept in view all through, was to demonstrate the essential unity of type of the British Calamites, *i.e.* that they are all Cryptogams, of equisetaceous affinities (though sometimes heterosporous), both possessing precisely the same mode of growth in thickness by means of a cambium, which is now characteristic of Dicotyledons and Gymnosperms.

[1] For a fuller account of Dr. Hansen's work, see the *Annals of Botany,* 1895.

His researches have given us a fairly complete knowledge of the organisation of these arborescent Horse-tails.

(2) The *Sphenophylleæ*, a remarkable group of vascular Cryptogams, unrepresented among living plants, but having certain characters in common both with *Lycopodiaceæ* and *Equisetaceæ*, are now very thoroughly known, owing, in a great degree, to Williamson's investigations. The discovery of the structure of the fructification, absolutely unique among Cryptogams, was in the first instance entirely his own.

(3) The *Lyginodendreæ*.—The existence of this family, which consists of plants with the foliage of ferns, but with stems and roots which recall those of Cycads, was revealed by Williamson. This appears to be the most striking case of an intermediate group yet found among fossil plants.

(4) The *Lycopodiaceæ*.—Williamson added enormously to our knowledge of this great family, and proved conclusively that *Sigillaria* and *Lepidodendron* are essentially similar in structure, both genera, as well as their allies, being true Lycopodiaceous Cryptogams, but with secondary growth in almost all cases. He demonstrated the relation between the vegetative organs and the fructification in many of these plants, and by his researches on *Stigmaria*, made known the structure of their subterranean parts. The different types of *Lepidodendron*, of which he investigated the structure, were so numerous as to place our knowledge of these plants on a broad and secure foundation. The paper was illustrated by lantern-slides, partly from Williamson's figures, and partly original.

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4. *The Localisation, the Transport, and Rôle of Hydrocyanic Acid in* Pangium edule, *Reinw. By* Dr. T. M. Treub, *Buitenzorg, Java.*

Five years ago Dr. Greshoff made the remarkable discovery that the poisonous substance contained in great quantities in all the parts of *Pangium edule*, was nothing else than hydrocyanic acid. This interesting chemical discovery was the starting-point of Dr. Treub's physiological investigations. In microchemical researches hydrocyanic acid presents a great advantage, as compared with the great majority of substances to be detected in tissues by reagents; namely, that the Prussian blue reaction, easily applicable in microchemical research, gives completely trustworthy results. The appearance of Prussian blue in a cell may be accepted as certain proof of the previous occurrence in the cell of hydrocyanic acid, no other substance producing the same reaction. The leaves prove to be the chief factories of hydrocyanic acid in *Pangium*, though there are other much smaller local factories of this substance in the tissues of other organs. The hydrocyanic acid formed in the leaves is conducted through the leaf-stalks to the stem, and distributed to the spots where plastic material is wanted. The acid travels in the phloem of the fibro-vascular bundles. Dr. Treub regards the hydrocyanic acid in *Pangium edule* as one of the first plastic materials for building up proteids; he thinks it is, in this plant, the first detectable, and perhaps the first formed product of the assimilation of inorganic nitrogen. In accordance with this hypothesis, the formation of hydrocyanic acid in *Pangium* depends, on the one hand, on the presence of carbo-hydrates or analogous products of the carbon-assimilation, and, on the other hand, on the presence of nitrates. These two points were proved, or at least rendered probable, by a great number of experiments made by Dr. Treub in the Buitenzorg Gardens. (The details of this investigation will be found in a paper published in the 'Annales de jardin botanique de Buitenzorg').

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5. *Exhibition of Models illustrating Karyokinesis. By* Professor J. Bretland Farmer.

Professor Farmer described a set of wax models illustrating the typical forms passed through, and the chief variations exhibited by, the chromosomes during the division of the nucleus in the spore-mother cells of plants. The wax employed is made of a mixture of one part of white wax, with five parts of paraffin, the melting point of which is about 50° C.

SATURDAY, SEPTEMBER, 14.

The Section did not meet.

MONDAY, SEPTEMBER 16.

A joint discussion with Section B was held on the Relation of Agriculture to Science. See p. 660.

The following Papers were read:—

1. *On the Destruction of a Cedar Tree at Kew by Lightning.* *By* W. T. Thiselton-Dyer, *F.R.S.*

The President of the Section exhibited photographs and specimens of a large cedar (*Cedrus Deodara,* Loud.) from Kew, which had been struck and completely shattered by lightning on August 10. It was pointed out that the main stem had been in part blown into matchwood by the violence of the shock, and branches were torn off with large portions of the trunk adhering to their base. The explosion seemed to have been centrifugal, the stem having been disrupted from the centre, and not merely stripped superficially.

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2. *On the Formation of Bacterial Colonies.* *By* Professor Marshall Ward, *F.R.S.*

The author has examined the details of development of the colony in numerous species from a single spore by employing microscopic plate-cultures, which can be kept under observation with a one-twelfth and even a one-twentieth oil-immersion lens, or by making pure *Klatschpräparate* on cover-slips covered with a thin film of gelatine.

He finds many factors of importance affecting the form, extent, rapidity of growth, and other characters of colonies; the elasticity of the gelatine, the presence of moist films on the surface of the gelatine, the rate of (slight) liquefaction, &c., all being of importance in explaining the shapes, &c., of submerged colonies—'whetstone shaped,' moruloid, spherical, or lobed colonies—the mode of emergence and spreading over the surface of the gelatine, the formation of radiating fringes, iridescent plates, &c.

Exposure to light during the development of liquefying colonies may profoundly affect their shape and other properties, a phenomenon closely connected with the retardation of liquefaction and growth. Pigment bacteria may give rise to perfectly colourless races when cultivated under certain conditions, and the colour restored by again changing the conditions; a fact which the author has not only confirmed with red forms, but which he shows to be true of a violet bacillus. Species commonly described as non-motile show active movements under certain conditions, and the sizes of bacteria are not constant in different regions of one and the same colony. Details have been worked out for series of types the extremes of which differ considerably in liquefying power, and essential difference in the appearance of a colony may depend on the amount of liquefying power evinced.

Some curious cases of travelling films, the lobes and contorted tresses of which move like amœbæ over the surface of the gelatine, were also examined.

The facts point to (1) differences in colonies even of one species may depend on much more subtle differences in cultures than are usually recognised; (2) varietal differences may occur in two bacilli of the same species (isolated from a river), due to the different vicissitudes the two individuals have been subjected to during their sojourn in the water; (3) the difficulties met with in diagnosing 'species' of bacteria with the aid of works of known authority are partly due to varieties of the same species being recorded by different observers under different names, and the author thinks some more consistent prearranged plan of working out the characters of such forms should be developed by bacteriologists than at present exists.

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3. *On a Supposed Case of Symbiosis in* Tetraplodon. *By* Professor F. E. Weiss.

The author exhibited specimens of *Tetraplodon* from the Cuchullin Hills in Skye, where it was found plentifully on animal excreta. In September he found many of the patches mixed with an orange-coloured *Peziza,* which did not appear to have in any way injured the moss plants. The rhizoids of the moss, however, contained in many cases fungal hyphæ closely resembling those of the *Peziza,* and though present in the cells of the moss these latter did not seem to be injured by them. He suggested that this might be a case of symbiosis; the moss, as in the case of other green plants, making use of the fungal hyphæ to obtain its nutriment from the organic material. The ultimate proof of such a case of symbiosis would, however, necessarily depend upon culture experiments, which he understood were now being made by another observer.

TUESDAY, SEPTEMBER 17.

The following Papers were read:—

1. *On Amber. By* Dr. Conwentz, *Danzig.*

The author of this paper gave an account of the Baltic and English amber, and their vegetable contents. After describing the different forms of Tertiary amber, he referred to the occurrence of succinite on the coasts of Essex, Suffolk, and Norfolk; the specimens are usually found with seaweed, thrown up by the tides. Occasionally pieces have been met with weighing over two pounds. Dr. Conwentz described the method of examining the plant fragments enclosed in amber, and compared the manner of preservation with that of recent plant sections mounted in Canada balsam. The amber was originally poured out from the roots, stems, and branches of injured or broken trees, in the form of resin, which on evaporation became thickened, and finally assumed the form of succinite or some similar substance. For the most part the fossil resin was derived from the stems and roots of coniferous trees of the genus *Pinus.* In addition to the exceptionally well-preserved tissues of coniferous trees, the Baltic amber has yielded remarkable specimens of monocotyledonous and dicotyledonous flowers. Some of the most striking examples were illustrated by means of the excellent coloured plates from Dr. Conwentz's monograph on the Baltic amber.[1]

[1] *Monographie der baltischen Bernsteinbäume.* Danzig, 1890

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2. *The Wealden Flora of England.* *By* A. C. SEWARD.

Mr. A. C. Seward, after referring to the various species described by Mantell, Carruthers, Starkie Gardner, and others, from the Wealden strata of England, briefly described a large number of plants from the British Museum collection. During the last few years Mr. Rufford, of Hastings, has obtained an extremely valuable and rich collection of plants from Ecclesbourne, Fairlight, and other localities; and these have now become the property of the nation. The following species are at present known from the Wealden of England; some of these have already been figured in the first volume of the catalogue of the Wealden flora, and the remainder are dealt with in the forthcoming second volume:—*Algites valdensis*, sp. nov., *A. catenelloides*, sp. nov., *Chara Knowltoni*, sp. nov., *Marchantites Zeilleri*, sp. nov., *Equisetites Lyelli*, Mant., *E. Burchardti*, Dunk., *E. Yokoyamæ*, sp. nov., *Onychiopsis Mantelli* (Brong.), *O. elongata* (Geyl.), *Acrostichopteris Ruffordi*, sp. nov., *Matonidium Göpperti* (Ett.), *Protopteris Witteana*, Schenk., *Ruffordia Göpperti* (Dunk.), *Cladophlebis longipennis*, sp. nov., *C. Albertsii* (Dunk.), *C. Browniana* (Dunk.), *C. Dunkeri* (Schimp.), *Sphenopteris Fontainei*, sp. nov., *S. Fittoni*, sp. nov., *Weichselia Mantelli* (Brong.), *Tæniopteris Beyrichii* (Schenk.), *T. Dawsoni*, sp. nov., *Sagenopteris Mantelli* (Dunk.), *S. acutifolia*, sp. nov., *Microdictyon Dunkeri*, Schenk., *Dictyophyllum Römeri*, Schenk., *Leckenbya valdensis*, gen. et sp. nov., *Tempskya Schimperi*, Cord., *Cycadites Römeri*, Schenk., *C. Saportæ*, sp. nov., *Dionites Dunkerianus* (Göpp.), *D. Brongniarti* (Mant.), *Nilssonia Schaumburgensis* (Dunk.), *Otozamites Klipsteinei* (Dunk.), *O. Göppertianus* (Dunk.), *Zamites Buchianus* (Ett.), *Zamites Carruthersi*, sp. nov., *Anomozamites Lyellianus* (Dunk.), *Cycadolepis*, *Carpolithes*, *Androstrobus Nathorsti*, sp. nov., *Conites elegans* (Carr.), *C. armatus*, sp. nov., *Bucklandia anomala* (Stokes and Webb), *Fittonia Ruffordi*, sp. nov., *Bennettites Saxbyanus* (Brown), *B. Gibsonianus*, Carr., *B.* (*Williamsonia*) *Carruthersi*, sp. nov., *Yatesia Morrisi*, Carr., *Withamia Saportæ*, gen. et sp. nov., *Beckleria anomala*, gen. et sp. nov., *Dichopteris*, sp., *Sphenolepidium Kurrianum* (Schenk.), *S. Sternbergianum* (Dunk.), *Pagiophyllum crassifolium*, Schenk., *Brachyphyllum obesum* (Heer), *B. spinosum*, sp. nov., *Pinites Solmsi*, sp. nov., *P. Dunkeri* (Carr.), *P. Mantelli* (Carr.), *P. patens* (Carr.), *P. Carruthersi* (Gard.), &c.

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3. *On the Diurnal Variation in the Amount of Diastase in Foliage Leaves.* *By* Professor J. REYNOLDS GREEN, *F.R.S.*

The diastase which is present in foliage leaves varies in amount during the day, being greatest in the early morning, and least after sunset. The variation has been ascertained to be chiefly, if not entirely, due to the action of the sunlight. The author showed last year, at the Oxford meeting, that diastatic extracts exposed to sunlight or electric light, without the interposition of any form of screen, had their activity largely impaired, the damage amounting sometimes to 70 per cent. Experiments made upon the living leaf of a scarlet-runner showed a similar destructive action of the light, the amount of destruction only amounting, however, to about 10 to 20 per cent. The author attributes the difference to the screening action of the proteids in the cells of the leaf.

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4. *On the Structure of Bacterial Cells.* *By* HAROLD WAGER.

In this paper an account was given of the present state of our knowledge of the cells of bacteria. Reference was made to the observations of Schottelius, Migula, De Bary, Bütschli, and others. The author showed that it is possible to demonstrate in the majority of bacterial cells the presence of two substances, one of which may be regarded as protoplasmic in nature, and a second which stains deeply when acted upon by fuchsin and kindred staining substances, and which may be regarded as nuclear. It was pointed out that this nuclear substance does not possess the structure of nuclei in the cells of higher plants.

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5. *On the Prothallus and Embryo of* Danæa. *By* G. Brebner.

Mr. Brebner gave an account of the prothallus and sexual organs of *Danæa simplicifolia*, Rudge, as the result of investigations made on some material from the Botanic Gardens in British Guiana. He pointed out that there is a close similarity between *Danæa* and the other two genera of the *Marattiaceæ*, *Angiopteris* and *Marattia*, of which the prothallus has been previously described. An interesting fact was noted as regards the prothallus rhizoids, which possess a distinctly septate structure, and so far resemble a moss protonema. Possibly similar septate rhizoids may be found in the other marattiaceous genera. The development of the antheridia of *Danæa* agrees in the main with that in *Marattia* and *Angiopteris*: the material did not allow of any developmental study of the archegonia. The concentric bundle of the primary embryonic stem shows an endodermal layer. On the whole the author found in *Danæa* a complete agreement, in all essential features, with *Angiopteris* and *Marattia*, as regards prothallus, reproductive organs, and embryo development.

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6. *On Cross and Self Fertilisation, with special reference to Pollen Prepotency.* *By* J. C. Willis.

The time has passed for regarding self-fertilisation as being always necessarily harmful in itself, and it is now recognised as a regular feature in the life-history of many plants. There exist many cases of plants in which both self and cross pollination occur nearly, or quite, simultaneously, and it is very desirable to know what happens in these cases. Darwin's experiments render it probable that prepotency of foreign pollen is usual. The author's experiments have been devoted to a study of the relative chemical attraction of 'own' and 'foreign' pollen by the same stigma (chiefly in gelatine and agar cultures), and have given negative results. It seems probable, putting together all the various known facts, that prepotency, where it occurs, is due to actions set up after the pollen tubes have entered the stigma, these actions tending to favour the growth of the 'foreign' pollen-tubes, and to check that of the 'own' pollen.

INDEX.

References to reports and papers printed in extenso *are given in Italics.*
*An Asterisk * indicates that the title only of the communication is given.*
The mark † indicates the same, but a reference is given to the Journal or Newspaper where the paper is published in extenso.

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Associates for the Meeting in 1895 may obtain the Volume for the Year at two-thirds of the Publication Price.

REPORT OF THE SIXTY-SECOND MEETING, at Edinburgh, August 1892, *Published at* £1 4*s.*

CONTENTS:—Report of the Corresponding Societies Committee;—Report on Meteorological Observations on Ben Nevis;—Seventh Report on Electrolysis in its Physical and Chemical Bearings;—Report on the Phenomena accompanying the Discharge of Electricity from Points;—Second Report on the Ultra-violet Rays of the Solar Spectrum;—Second Report on the Application of Photography to the Elucidation of Meteorological Phenomena;—Twelfth Report on the Earthquake and Volcanic Phenomena of Japan;—Nineteenth Report on the Rate of Increase of Underground Temperature downwards in various Localities of Dry Land and under Water;—Report of the Committee for constructing and issuing Practical Standards for use in Electrical Measurements;—Report on Electro-optics;—Eighth Report on the best methods of recording the direct Intensity of Solar Radiation;—Report on Constants and Units;—On the Application of Interference Methods to Spectroscopic Measurements;—Fourth Report on establishing an International Standard for the Analysis of Iron and Steel;—Sixth Report on Isomeric Naphthalene Derivatives;—Fourth Report on the Bibliography of Spectroscopy;—Report on the Action of Light on the Hydracids of the Halogens in presence of Oxygen;—Report on Wave-length Tables of the Spectra of the Elements and Compounds;—Sixth Report on the Bibliography of Solution;—Sixth Report on the Nature of Solution;—Report (provisional) on the Formation of Haloids from pure Materials;—Report (provisional) on the Influence of the Silent Discharge of Electricity on Oxygen and other Gases;—Report (provisional) on the Action of Light upon Dyed Colours;—Report on the Proximate Constituents of the various kinds of Coal;—Eighteenth Report on the Circulation of the Underground Waters in the Permeable Formations of England, and the Quality and Quantity of the Waters supplied to various Towns and Districts from these Formations;—Report on the Investigation of the Cave at Elbolton;—Twentieth Report on Erratic Blocks;—Third Report on the Registration of the Type Specimens of British Fossils;—Third Report on the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest;—Ninth Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Report on the Cretaceous Polyzoa;—Report on the Volcanic Phenomena of Vesuvius and its neighbourhood;—Report on the advisability and possibility of establishing in other parts of the country observations upon the prevalence of Earth Tremors similar to those now being made in Durham in connection with coal-mine explosions;—Report on work done at the Zoological Station at Naples;—Fifth Report on the present state of our Knowledge of the Zoology and Botany of the West India Islands, and the steps taken to investigate ascertained deficiencies in the Fauna and Flora;—Second Report on the present state of our Knowledge of the Zoology of the Sandwich Islands, and the steps taken to investigate ascertained deficiencies in the Fauna;—Report on the occupation of a Table at the Laboratory of the Marine Biological Association at Plymouth;—Sixth Report on the establishment of a Botanical Laboratory at Peradeniya, Ceylon;—Report of the Committee for making a Digest of the Observations on the Migration of Birds at Lighthouses and Light-vessels;—Report on a Deep-sea Tow-net for opening and closing under Water;—Report on proposals for the Legislative Protection of Wild Birds' Eggs;—Report on the Climatological and Hydrographical Conditions of Tropical Africa;—Report on the Teaching of Science in Elementary Schools;—Second Report on the Development of Graphic Methods in Mechanical Science;—Shield Tunnelling in Loose Ground under Water Pressure, with special reference to the Vyrnwy Aqueduct Tunnel under the Mersey;—Report of the Committee for editing a new Edition of 'Anthropological Notes and Queries;'—Report on the Ruins of Mashonaland and the Habits and Customs of the inhabitants;—Report on the Prehistoric and Ancient Remains of Glamorganshire;—Eighth Report on the Physical Characters, Languages, and Industrial and Social Condition of the North-Western Tribes of the Dominion of Canada;—Report on the Habits, Customs, Physical Characteristics, and Religions of the Natives of India;—Report on the work done in the Anthropometric Laboratory.

Together with the Transactions of the Sections, Sir Archibald Geikie's Address, and Resolutions of the General Committee of the Association.

REPORT OF THE SIXTY-THIRD MEETING, at Nottingham, September 1893, *Published at £1 4s.*

CONTENTS:—Address by the President, Professor Burdon Sanderson;—Report of the Corresponding Societies Committee;—Report on the Tables connected with the Pellian Equation from the Point where the work was left by Degen in 1817;—Interim Report on the Establishment of a National Physical Laboratory;—Interim Report on the best means of Comparing and Reducing Magnetic Observations;—Report on Electro-optics;—Report on Magnetic Work at the Falmouth Observatory;—Report on Practical Standards for Electrical Measurements;—Third Report on the Application of Photography to the Elucidation of Meteorological Phenomena;—Ninth Report on the best methods of recording the direct Intensity of Solar Radiation;—Report on the present state of our Knowledge in Electrolysis and Electrochemistry;—Thirteenth Report on the Earthquake and Volcanic Phenomena of Japan;—Interim Report on the Bibliography of Spectroscopy;—Report of the Committee for Calculating Tables of certain Mathematical Functions;—Report on Meteorological Observations on Ben Nevis;—Report on Earth Tremors;—The Action of Magnetism on Light, with a critical correlation of the various Theories of Light-propagation, by J. Larmor;—Interim Report on the Bibliography of Solution;—Report on the Action of Light upon Dyed Colours;—Seventh Report on Isomeric Naphthalene Derivatives;—Report on Wave-length Tables of the Spectra of the Elements and Compounds:—Fifth Report on establishing an International Standard for the Analysis of Iron and Steel;—Report on Solution;—Report on the Influence of the Silent Discharge of Electricity on Oxygen and other Gases;—Bacteriology in its Relations to Chemical Science, by Percy Frankland;—Nineteenth Report on the

Circulation of Underground Waters;—Tenth Report on the Phyllopoda of the Palæozoic Rocks;—Report on the Eurypterid-bearing Deposits of the Pentland Hills;—Report on the Volcanic Phenomena of Vesuvius and its Neighbourhood;—Report on the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest in the United Kingdom;—Fourth Report on the Registration of the Type Specimens of British Fossils;—Report on the Character of the High-level Shell-bearing Deposits at Clava, Chapelhall, and other localities;—Twenty-first Report on the Erratic Blocks of England, Wales, and Ireland;—Third Report on the present state of our Knowledge of the Zoology of the Sandwich Islands;—Interim Report of the Committee for making a Digest of the Observations on the Migration of Birds at Lighthouses and Light-vessels;—Sixth Report on the present state of our Knowledge of the Zoology and Botany of the West India Islands;—Report on the Marine Zoology of the Irish Sea;—Report on the Occupation of a Table at the Zoological Station at Naples;—Report on Investigations made at the Laboratory of the Marine Biological Association, Plymouth;—Report on the Physiological Action of the Inhalation of Oxygen in Asphyxia, more especially in Coal Mines;—Report on the Legislative Protection of Wild Birds' Eggs;—Report on the Compilation of an Index Generum et Specierum Animalium;—Report on Scottish Place-names;—Report on the Exploration of Ancient Remains in Abyssinia;—Report on the Exploration of the Glacial Region of the Karakoram Mountains;—Report on the Teaching of Science in Elementary Schools;—Interim Report on the Methods of Economic Training adopted in this and other Countries;—Report on the Climatological and Hydrographical Conditions of Tropical Africa;—Interim Report on the Dryness of Steam in Boiler Trials;—Report on the Development of Graphic Methods in Mechanical Science, by H. Hele-Shaw;—Report on the Physical Deviations from the Normal among Children in Elementary and other Schools;—First Report on the Ethnographical Survey of the United Kingdom;—Interim Report on the North-Western Tribes of Canada;—Report of the Anthropometric Laboratory Committee;—Report on Uniformity in the Spelling of Barbaric and Savage Languages and Race-names;—The Automatic Balance of Reciprocating Mechanism, by W. Worby Beaumont.

Together with the Transactions of the Sections.

REPORT OF THE SIXTY-FOURTH MEETING, at Oxford, August 1894, *Published at £1 4s.*

CONTENTS:—Address by the President, The Most Hon. the Marquis of Salisbury;—Report of the Corresponding Societies Committee;—Report on the present state of our Knowledge of Thermodynamics;—Tenth Report on the Best Methods of Recording the Direct Intensity of Solar Radiation;—Twentieth Report on Underground Temperature;—Report on Meteorological Observations on Ben Nevis;—Report on Practical Standards for Electrical Measurements;—Fourth Report on the Application of Photography to the Elucidation of Meteorological Phenomena;—Report on Earth Tremors;—Report on the Electrolytic Methods of Quantitative Analysis;—Report on the Bibliography of Spectroscopy;—Sixth Report on an International Standard for the Analysis of Iron and Steel;—Report on the Action of Light upon Dyed Colours;—Interim Report on the Bibliography of Solution;—Interim Report on the Proximate Chemical Constituents of Coal;—Report on Wave-length Tables of the Speotra of the Elements and Compounds;—Eighth Report on Isomeric Naphthalene Derivatives;—Report on the Investigation of the Cave at Elbolton in order to ascertain whether the Remains of Palæolithic Man occur in the Lower Cave Earth;—Eleventh Report on the Fossil Phyllopoda of the Palæozoic Rocks;—Report on the Exploration of the Calf Hole Cave at the Heights, Skyrethorns, near Skipton;—Fifth Report on the Collection, Preservation, and Systematic Registration of Photographs of Geological Interest in the United Kingdom;—Twentieth Report on the Circulation of Underground Waters;—Second Report on the Eurypterid-bearing Deposits of the Pentland Hills;—Report on the Stonesfield Slate;—Report on the Character of the High-level Shell-bearing Deposits at Clava, Chapelhall, and other Localities (Chapelhall Section);—Report on the Volcanic Phenomena of Vesuvius and its Neighbourhood;—Second Report on the Marine Zoology of the Irish Sea;—Occupation of a Table at the Zoological Station at Naples;—Fourth Report on the Zoology of the Sandwich Islands;—Seventh Report on the present state of our Knowledge of the Zoology and Botany of the West India Islands;—Report on Investigations made at the Laboratory of the Marine Biological Association, Plymouth;—Interim Report on the Influence of Previous Fertilisation of the Female on her Subsequent Offspring, and the Effect of Maternal Impressions during Pregnancy on the Offspring;—Report on the Compilation of an Index Generum et Specierum Animalium;—Report on Proposals for the Legislative Protection of Wild Birds' Eggs;—Interim Report of the Committee for making a Digest of the Observations on the Migration of Birds at Lighthouses and Lightvessels;—Third Report on the Climatological and Hydrographical Conditions of Tropical Africa;—Report on the Exploration of Hadramout, Southern Arabia;—Report of the Committee for making Geographical, Meteorological, and Natural History Observations in South Georgia or other Antarctic Island;—Report on the Teaching of Science in Elementary Schools;—Report on the Methods of Economic Training in this and other Countries;—Report on Methods of determining the Dryness of Steam;—Second Report on the Prehistoric and Ancient Remains of Glamorganshire;—Second Report on the Ethnographical Survey of the United Kingdom;—Report on the Lake Village of Glastonbury;—Report on the Physical and Mental Deviations from the Normal among Children in Public Elementary and other Schools;—Report on Anthropometric Work in Schools;—Report on the Anthropometric Laboratory at Nottingham;—Ninth Report on the North-Western Tribes of Canada;—Report on the Structure and Function of the Mammalian Heart;—On recent Researches in the Infra-red Spectra;—On the Formation of Soap-bubbles by the Contact of Alkaline Oleates with Water;—On the Displacements of the Rotational Axis of the Earth;—A Lecture-room Experiment to illustrate Fresnel's Diffraction Theory and Babinet's Principle;—The Connection between Chemical Combination and the Discharge of Electricity through Gases;—On the Electrification of Molecules and Chemical Change;—Report on Planimeters;—On Methods that have been adopted for Measuring Pressures in the Bores of Guns.

Together with the Transactions of the Sections.

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Report on Planimeters, by Prof. O. Henrici, F.R.S., 1894, 1*s.*

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THE ADVANCEMENT OF SCIENCE.

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Year of Election.

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1881. *Abbott, R. T. G. Whitley House, Malton.
1887. ‡Abbott, T. C. Eastleigh, Queen's-road, Bowdon, Cheshire.
1863. *ABEL, Sir FREDERICK AUGUSTUS, Bart., K.C.B., D.C.L., D.Sc., F.R.S., V.P.C.S., President of the Government Committee on Explosives. The Imperial Institute, Imperial Institute-road, and 2 Whitehall-court, London, S.W.
1886. ‡*Abercromby, The Hon. Ralph, F.R.Met.Soc. 21 Chapel-Street, Belgrave-square, London, S.W.*
1885. *ABERDEEN, The Right Hon. the Earl of, G.C.M.G., LL.D. 37 Grosvenor-square, London, W.
1885. ‡Aberdeen, The Countess of. 37 Grosvenor-square, London, W.
1885. ‡Abernethy, David W. Ferryhill Cottage, Aberdeen.
1863. *ABERNETHY, JAMES, M.Inst.C.E., F.R.S.E. 4 Delahay-street, Westminster, S.W.
1885. ‡Abernethy, James W. 2 Rubislaw-place, Aberdeen.

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1886. ‡Abraham, Harry. 147 High-street, Southampton.
1877. ‡Ace, Rev. Daniel, D.D., F.R.A.S. Laughton, near Gainsborough, Lincolnshire.
1884. ‡Acheson, George. Collegiate Institute, Toronto, Canada.
1873. ‡Ackroyd, Samuel. Greaves-street, Little Horton, Bradford, Yorkshire.
1882. *Acland, Alfred Dyke. 38 Pont-street, Chelsea, London, S.W.
1869. ‡Acland, Charles T. D. Sprydoncote, Exeter.
1877. *Acland, Captain Francis E. Dyke, R.A. Woodmansterne Rectory, Banstead, Surrey.
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1894. *Acland, Henry Dyke, F.G.S. The Old Bank, Great Malvern.
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1879. *ADAMS, Rev. THOMAS, M.A., D.C.L., Principal of Bishop's College, Lennoxville, Canada.
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1884. ‡Agnew, Cornelius R. 266 Maddison-avenue, New York, U.S.A.
1887. ‡Agnew, William. Summer Hill, Pendleton, Manchester.
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1864. *Ainsworth, David. The Flosh, Cleator, Carnforth.
1871. *Ainsworth, John Stirling. Harecroft, Cumberland.
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1891. *Aisbitt, M. W. Mountstuart-square, Cardiff.
1871. §AITKEN, JOHN, F.R.S., F.R.S.E. Darroch, Falkirk, N.B.
1884. *Alabaster, H. Hazeldene, Wood-vale, Honor Oak, London, S.E.
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1894. §§Alexander, A. W. Blackwall Lodge, Halifax.
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1888. *Alexander, Patrick Y. 47 Victoria-street, Westminster, S.W.
1873. ‡Alexander, Reginald, M.D. 13 Hallfield-road, Bradford, Yorkshire.

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1883. ‡Alger, Miss Ethel. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, W. H. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, Mrs. W. H. The Manor House, Stoke Damerel, South Devon.
1867. ‡Alison, George L. C. Dundee.
1885. ‡Allan, David. West Cults, near Aberdeen.
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1887. *Allen, Charles Peter. Overbrook, Kersal, Manchester.
1888. §Allen, F. J. Mason College, Birmingham.
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1891. ‡Allen, Henry A., F.G.S. Geological Museum, Jermyn-street, London, S.W.
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1861. ‡Allen, Richard. Didsbury, near Manchester.
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1886. ‡Allport, Samuel, F.G.S. 50 Whittall-street, Birmingham.
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1873. ‡Ambler, John. North Park-road, Bradford, Yorkshire.
1891. ‡Ambrose, D. R. Care of Messrs. J. Evans & Co., Bute Docks, Cardiff.
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1883. §Amery, Peter Fabyan Sparke. Druid, Ashburton, Devon.
1884. ‡Ami, Henry, F.G.S. Geological Survey, Ottawa, Canada.
1885. ‡Anderson, Charles Clinton. 4 Knaresborough-place, Cromwell-road, London, S.W.
1850. ‡*Anderson, Charles William. Belvedere, Harrogate.*
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1888. *Anderson, R. Bruce. 35A Great George-street, London, S.W.
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1889. ‡Anderson, Robert Simpson. Elswick Collieries, Newcastle-upon-Tyne.
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1886. *ANDERSON, WILLIAM, C.B., D.C.L., F.R.S., M.Inst.C.E., Director-General of Royal Ordnance Factories. Lesney House, Erith, Kent.
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1891. ‡Andrews, Thomas. 163 Newport-road, Cardiff.

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1878. ‡Anson, Frederick H. 15 Dean's-yard, Westminster, S.W.
1890. §Antrobus, J. Coutts. Eaton Hall, Congleton.
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1894. §Archibald, A. Bank House, Ventnor.
1884. *Archibald, E. Douglas. Care of Mr. F. Tate, 28 Market-street, Melbourne.
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1883. §Armistead, Richard. 33 Chambres-road, Southport.
1883. *Armistead, William. 15 Rupert-street, Compton-road, Wolverhampton.
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1867. **Armitstead, George. Errol Park, Errol, N.B.*
1857. *ARMSTRONG, The Right Hon. Lord, C.B., LL.D., D.C.L., F.R.S. Cragside, Rothbury.
1879. *ARMSTRONG, Sir ALEXANDER, K.C.B., M.D., LL.D., F.R.S., F.R.G.S. The Albany, London, W.
1886. ‡ARMSTRONG, GEORGE FREDERICK, M.A., F.R.S.E., F.G.S., Regius Professor of Engineering in the University of Edinburgh. The University, Edinburgh.
1873. *ARMSTRONG, HENRY E., Ph.D., LL.D., F.R.S., Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, London, S.W. 55 Granville Park, Lewisham, S.E.
1876. ‡Armstrong, James. Bay Ridge, Long Island, New York, U.S.A.
1889. ‡Armstrong, John A. 32 Eldon-street, Newcastle-upon-Tyne.
1884. ‡Armstrong, Robert B. Junior Carlton Club, Pall Mall, London, S.W.
Armstrong, Thomas. Higher Broughton, Manchester.
1889. ‡Armstrong, Thomas John. 14 Hawthorn-terrace, Newcastle-upon-Tyne.
1893. §§Arnold-Bemrose, H., M.A., F.G.S. 56 Friar-gate, Derby.
1870. ‡Arnott, Thomas Reid. Bramshill, Harlesden Green, London, N.W.
1853. **Arthur, Rev. William, M.A. Clapham Common, London, S.W.*
1886. ‡Ascough, Jesse. Patent Borax Company, Newmarket-street, Birmingham.
1870. *Ash, Dr. T Linnington. Holsworthy, North Devon.
1874. ‡Ashe, Isaac, M.B. Dundrum, Co. Dublin.
1889. §Ashley, Howard M. Airedale, Ferrybridge, Yorkshire.
ASHTON, THOMAS, J.P. Ford Bank, Didsbury, Manchester.
1887. ‡Ashton, Thomas Gair, M.A. 36 Charlotte-street, Manchester.
1866. ‡Ashwell, Henry. Woodthorpe, Nottingham.
*Ashworth, Edmund. Egerton Hall, Bolton-le-Moors.
1887. ‡Ashworth, Mrs. Harriet. Thorne Bank, Heaton Moor, near Stockport.
Ashworth, Henry. Turton, near Bolton.
1888. *Ashworth, J. J. 39 Spring-gardens, Manchester.
1890. ‡Ashworth, J. Reginald. 20 King-street, Rochdale.

Year of Election.

1887. ‡Ashworth, John Wallwork, F.G.S. Thorne Bank, Heaton Moor, near Stockport.
1887. ‡Aspland, Arthur P. Werneth Lodge, Gee Cross, near Manchester.
1875. *Aspland, W. Gaskell. Birchwood-grove, Burgess Hill, Sussex.
1861. §Asquith, J. R. Infirmary-street, Leeds.
1861. ‡Aston, Theodore. 11 New-square, Lincoln's Inn, London, W.C.
1887. §Atkinson, Rev. C. Chetwynd, M.A. Fairfield House, Ashton-on-Mersey.
1865. *Atkinson, Edmund, Ph.D., F.C.S. Portesbery Hill, Camberley, Surrey.
1884. ‡Atkinson, Edward, Ph.D., LL.D. Brookline, Massachusetts, U.S.A.
1894. §Atkinson, George M. 28 St. Oswald's-road, London, S.W.
1894. *Atkinson, Harold W. Erwood, Beckenham, Kent.
1861. ‡Atkinson, Rev. J. A. The Vicarage, Bolton.
1881. ‡Atkinson, J. T. The Quay, Selby, Yorkshire.
1881. ‡Atkinson, Robert William, F.C.S. 44 Loudoun-square, Cardiff.
1894. §Atkinson, William. Erwood, Beckenham, Kent.
1863. *Attfield, Professor J., M.A., Ph.D., F.R.S., F.C.S. 17 Bloomsbury-square, London, W.C.
1884. ‡Auchincloss, W. S. 209 Church-street, Philadelphia, U.S.A.
1886. ‡Aulton, A. D., M.D. Walsall.
1860. *Austin-Gourlay, Rev. William E. C., M.A. Kincraig, Winchester.
1881. ‡*Axon, W. E. A. Fern Bank, Higher Broughton, Manchester.*
1888. ‡Ayre, Rev. J. W., M.A. 30 Green-street, Grosvenor-square, London, W.
1877. *Ayrton, W. E., F.R.S., Professor of Applied Physics in the City and Guilds of London Institute, Central Institution, Exhibition-road, London, S.W.

1884. ‡Baby, The Hon. G. Montreal, Canada.
Backhouse, Edmund. Darlington.
1863. ‡Backhouse, T. W. West Hendon House, Sunderland.
1883. *Backhouse, W. A. St. John's Wolsingham, near Darlington.
1887. *Bacon, Thomas Walter. 4 Lyndhurst-road, Hampstead, London, N.W.
1887. ‡Baddeley, John. 1 Charlotte-street, Manchester.
1881. ‡Baden-Powell, Sir George S., K.C.M.G., M.A., M.P., F.R.A.S., F.S.S. 114 Eaton-square, London, S.W.
1877. ‡Badock, W. F. Badminton House, Clifton Park, Bristol.
1883. ‡Baildon, Dr. 65 Manchester-road, Southport.
1892. §Baildon, H. Bellyse. Duncliffe, Murrayfield, Edinburgh.
1883. *Bailey, Charles, F.L.S. Ashfield, College-road, Whalley Range, Manchester.
1893. §Bailey, Colonel F., Sec. R.Scot.G.S., F.R.G.S. Edinburgh.
1870. ‡Bailey, Dr. Francis J. 51 Grove-street, Liverpool.
1887. *Bailey, G. H., D.Sc., Ph.D. Owens College, Manchester.
1865. ‡Bailey, Samuel, F.G.S. Ashley House, Calthorpe-road, Edgbaston, Birmingham.
1855. ‡Bailey, William. Horseley Fields Chemical Works, Wolverhampton.
1887. ‡Bailey, W. H. Summerfield, Eccles Old-road, Manchester.
1866. ‡Baillon, Andrew. British Consulate, Brest.
1894. *Baily, Francis Gibson, M.A. University College, Liverpool.
1878. ‡Baily, Walter. 4 Roslyn-hill, London, N.W.
1885. ‡Bain, Alexander, M.A., LL.D. Ferryhill Lodge, Aberdeen.
1873. ‡Bain, Sir James, M.P. 3 Park-terrace, Glasgow.
1885. ‡Bain, William N. Collingwood, Pollokshields, Glasgow.

Year of Election.

1882. *BAKER, Sir BENJAMIN, K.C.M.G., LL.D., F.R.S., M.Inst.C.E. 2 Queen Square-place, Westminster, S.W.
1891. ‡Baker, J. W. 50 Stacey-road, Cardiff.
1881. ‡Baker, Robert, M.D. The Retreat, York.
1875. ‡BAKER, W. PROCTOR. Brislington, Bristol.
1881. ‡Baldwin, Rev. G. W. de Courcy, M.A. Lord Mayor's Walk, York.
1884. ‡Balete, Professor E. Polytechnic School, Montreal, Canada.
1871. ‡Balfour, G. W., M.P. Whittinghame, Prestonkirk, Scotland.
1894. §§Balfour, Henry, M.A. 11 Norham-gardens, Oxford.
1875. ‡BALFOUR, ISAAC BAYLEY, M.A., D.Sc., M.D., F.R.S., F.R.S.E., F.L.S., Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1878. *Ball, Charles Bent, M.D. 24 Merrion-square, Dublin.
1866. *BALL, Sir ROBERT STAWELL, LL.D., F.R.S., F.R.A.S., Director of the Observatory and Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.
1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1886. ‡Ballantyne, J. W., M.B. 24 Melville-street, Edinburgh.
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1890. §§Bamford, Professor Harry, B.Sc. McGill University, Montreal, Canada.
1882. ‡Bance, Colonel Edward, J.P. Limewood, The Avenue, Southampton.
1884. ‡Barbeau, E. J. Montreal, Canada.
1866. ‡Barber, John. Long-row, Nottingham.
1884. ‡Barber, Rev. S. F. West Raynham Rectory, Swaffham, Norfolk.
1890. *Barber-Starkey, W. J. S. Aldenham Park, Bridgnorth, Salop.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
1894. §Barclay, Arthur. 3 Castle-street East, Oxford-street, London, W.
1871. ‡Barclay, George. 17 Coates-crescent, Edinburgh.
1852. *Barclay, J. Gurney. 54 Lombard-street, London, E.C.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1876. *Barclay, Robert. 21 Park-terrace, Glasgow.
1887. *Barclay, Robert. Springfield, Kersal, Manchester.
1886. ‡Barclay, Thomas. 17 Bull-street, Birmingham.
1881. ‡Barfoot, William, J.P. Whelford-place, Leicester.
1882. ‡Barford, J. D. Above Bar, Southampton.
1886. ‡Barham, F. F. Bank of England, Birmingham.
1890. ‡Barker, Alfred, M.A., B.Sc. Aske's Hatcham School, New Cross, London, S.E.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgford Rectory, Nottingham.
1879. ‡Barker, Elliott. 2 High-street, Sheffield.
1882. *Barker, Miss J. M. Hexham House, Hexham.
1879. *Barker, Rev. Philip C., M.A., LL.B. Boroughbridge Vicarage, Bridgwater, and Athelnay Station, Somerset.
1865. ‡*Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.*
1870. ‡BARKLY, Sir HENRY, G.C.M.G., K.C.B., F.R.S., F.R.G.S. 1 Bina-gardens, South Kensington, London, S.W.
1886. ‡Barling, Gilbert. 85 Edmund-street, Edgbaston, Birmingham.
1873. ‡Barlow, Crawford, B.A., M.Inst.C.E. 2 Old Palace-yard, Westminster, S.W.
1889. §Barlow, H. W. L. Holly Bank, Croftsbank-road, Urmston, near Manchester.

Year of Election.

1883. ‡Barlow, J. J. 37 Park-street, Southport.
1878. ‡Barlow, John, M.D., Professor of Physiology in Anderson's College, Glasgow.
1883. ‡Barlow, John R. Greenthorne, near Bolton.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
1885. *BARLOW, WILLIAM, F.G.S. Hillfield, Muswell Hill, London, N.
1873. ‡BARLOW, WILLIAM HENRY, F.R.S., M.Inst.C.E. 2 Old Palace-yard, Westminster, S.W.
1861. *Barnard, Major R. Cary, F.L.S. Bartlow, Leckhampton, Cheltenham.
1881. ‡Barnard, William, LL.B. 3 New-court, Lincoln's Inn, London, W.C.
1889. ‡Barnes, J. W. Bank, Durham.
1868. §Barnes, Richard H. Heatherlands, Parkstone, Dorset.
1884. ‡Barnett, J. D. Port Hope, Ontario, Canada.
1881. ‡BARR, ARCHIBALD, D.Sc., M.Inst.C.E. The University, Glasgow.
1890. ‡Barr, Frederick H. 4 South-parade, Leeds.
1895. §Barr, James Mark. Central Technical College, London. E.C.
1859. ‡Barr, Lieut.-General. Apsleytoun, East Grinstead, Sussex.
1891.§§Barrell, Frank R., M.A., Professor of Mathematics in University College, Bristol.
1883. ‡Barrett, John Chalk. Errismore, Birkdale, Southport.
1883. ‡Barrett, Mrs. J. C. Errismore, Birkdale, Southport.
1860. ‡Barrett, T. B. 20 Victoria-terrace, Welshpool, Montgomery.
1872. *BARRETT, W. F., F.R.S.E., M.R.I.A., Professor of Physics in the Royal College of Science, Dublin.
1883. ‡Barrett, William Scott. Abbotsgate, Huyton, near Liverpool.
1887. ‡Barrington, Miss Amy. Fassaroe, Bray, Co. Wicklow.
1874. *BARRINGTON, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.
1874. *Barrington-Ward, Mark J., M.A., F.L.S., F.R.G.S., H.M. Inspector of Schools. Thorneloe Lodge, Worcester.
1885. *Barron, Frederick Cadogan, M.Inst.C.E. Nervion, Beckenham-grove, Shortlands, Kent.
1881. ‡BARRON, G. B., M.D. Summerseat, Southport.
1866. ‡Barron, William. Elvaston Nurseries, Borrowash, Derby.
1893. ‡Barrow, George, F.G.S. Geological Survey Office, 28 Jermyn-street, London, S.W.
1886. ‡Barrow, George William. Baldraud, Lancaster.
1886. ‡Barrow, Richard Bradbury. Lawn House, 13 Ampton-road, Edgbaston, Birmingham.
1886. ‡Barrows, Joseph. The Poplars, Yardley, near Birmingham.
1886. ‡Barrows, Joseph, jun. Ferndale, Harborne-road, Edgbaston, Birmingham.
1858. ‡BARRY, Right Rev. ALFRED, D.D., D.C.L. The Cloisters, Windsor.
1862. *BARRY, CHARLES. 1 Victoria-street, London, S.W.
1883. ‡Barry, Charles E. 1 Victoria-street, London, S.W.
1875. ‡Barry, John Wolfe, C.B., F.R.S., M.Inst.C.E. 23 Delahay-street, Westminster, S.W.
1881. ‡Barry, J. W. Duncombe-place, York.
1884. *Barstow, Miss Frances. Garrow Hill, near York.
1890. *Barstow, J. J. Jackson. The Lodge, Weston-super-Mare.
1890. *Barstow, Mrs. The Lodge, Weston-super-Mare.
1892. ‡Bartholomew, John George, F.R.S.E., F.R.G.S. 12 Blacket-place, Edinburgh.
1858. *Bartholomew, William Hamond. Ridgeway House, Cumberland-road, Headingley, Leeds.

Year of Election.

1884. ‡Bartlett, James Herbert. 148 Mansfield-street, Montreal, Canada.
1873. ‡Bartley, George C. T., M.P. St. Margaret's House, Victoria-street, London, S.W.
1892. ‡Barton, Miss. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1893. ‡Barton, Edwin H., B.Sc. University College, Nottingham.
1884. ‡Barton, H. M. Foster-place, Dublin.
1852. ‡Barton, James. Farndreg, Dundalk.
1892. ‡Barton, William. 4 Glenorchy-terrace, Mayfield, Edinburgh.
1887. ‡Bartrum, John S. 13 Gay-street, Bath.
*Bashforth, Rev. Francis, B.D. Minting Vicarage, near Horncastle.
1876. ‡Bassano, Alexander. 12 Montagu-place, London, W.
1876. ‡Bassano, Clement. Jesus College, Cambridge.
1888. *Basset, A. B., M.A., F.R.S. Fledborough Hall, Holyport, Berkshire.
1891. ‡Bassett, A. B. Cheverell, Llandaff.
1866. *Bassett, Henry. 26 Belitha-villas, Barnsbury, London, N.
1889. ‡Bastable, Professor C. F., M.A., F.S.S. 6 Trevelyan-terrace, Rathgar, Co. Dublin.
1869. ‡Bastard, S. S. Summerland-place, Exeter.
1871. ‡Bastian, H. Charlton, M.A., M.D., F.R.S., F.L.S., Professor of the Principles and Practice of Medicine in University College, London. 8a Manchester-square, London, W.
1889. ‡Batalha-Reis, J. Portuguese Consulate, Newcastle-upon-Tyne.
1883. ‡Bateman, A. E., C.M.G. Board of Trade, London, S.W.
1868. ‡Bateman, Sir F., M.D., LL.D. Upper St. Giles's-street, Norwich.
Bateman, James, M.A., F.R.S., F.R.G.S., F.L.S. Home House, Worthing.
1889. ‡Bates, C. J. Heddon, Wylam, Northumberland.
1884. ‡Bateson, William, M.A., F.R.S. St. John's College, Cambridge.
1881. *Bather, Francis Arthur, M.A., F.G.S. 207 Harrow-road, London, W.
1836. ‡Batten, Edmund Chisholm. Thorn Falcon, near Taunton, Somerset.
1863. §Bauerman, H., F.G.S. 14 Cavendish-road, Balham, London, S.W.
1867. ‡Baxter, Edward. Hazel Hall, Dundee.
1892. §§Bayly, F. W. Royal Mint, London, E.
Bayly, John. Seven Trees, Plymouth.
1875. *Bayly, Robert. Torr-grove, near Plymouth.
1876. *Baynes, Robert E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 2 Norham-gardens, Oxford.
1887. ‡*Baynton, Alfred. 28 Gilda Brook Park, Eccles, Manchester.*
1883. *Bazley, Gardner. Hatherop Castle, Fairford, Gloucestershire.
Bazley, Sir Thomas Sebastian, Bart., M.A. Hatherop Castle, Fairford, Gloucestershire.
1886. ‡Beale, C. Calle Progress No. 83, Rosario de Santa Fé, Argentine Republic.
1886. ‡Beale, Charles G. Maple Bank, Edgbaston, Birmingham.
1860. *Beale, Lionel S., M.B., F.R.S., Professor of the Principles and Practice of Medicine in King's College, London. 61 Grosvenor-street, London, W.
1882. §Beamish, Lieut.-Colonel A. W., R.E. 27 Philbeach-gardens, London, S.W.
1884. ‡Beamish, G. H. M. Prison, Liverpool.
1872. ‡Beanes, Edward, F.C.S. Moatlands, Paddock Wood, Brenchley, Kent.
1883. ‡Beard, Mrs. Oxford.
1889. §Beare, Professor T. Hudson, F.R.S.E. University College, London, W.C.
1887. ‡Beaton, John, M.A. 219 Upper Brook-street, Chorlton-on-Medlock, Manchester.

Year of Election.

1842. *Beatson, William. Ash Mount, Rotherham.
1889. ‡Beattie, John. 5 Summerhill-grove, Newcastle-upon-Tyne.
1855. *Beaufort, W. Morris, F.R.A.S., F.R.G.S., F.R.M.S., F.S.S. 18 Piccadilly, London, W.
1886. ‡Beaugrand, M. H. Montreal.
1861. *Beaumont, Rev. Thomas George. Oakley Lodge, Leamington.
1887. *Beaumont, W. J. Emmanuel College, Cambridge.
1885. §BEAUMONT, W. W., M.Inst.C.E., F.G.S. Melford, Palace-road, Tulse Hill, London, S.W.
1871. *Beazley, Lieut.-Colonel George G. 74 Redcliffe-square, London, S.W.
1887. *BECKETT, JOHN HAMPDEN. Corbar Hill House, Buxton, Derbyshire.
1885. §BEDDARD, FRANK E., M.A., F.R.S., F.Z.S., Prosector to the Zoological Society of London. Society's Gardens, Regent's Park, London, N.W.
1870. §BEDDOE, JOHN, M.D., F.R.S. The Chantry, Bradford-on-Avon.
1858. §Bedford, James. Woodhouse Cliff, near Leeds.
1890. ‡Bedford, James E., F.G.S. Shireoak-road, Leeds.
1891. §Bedlington, Richard. Gadlys House, Aberdare.
1878. ‡BEDSON, P. PHILLIPS, D.Sc., F.C.S., Professor of Chemistry in the College of Physical Science, Newcastle-upon-Tyne.
1884. ‡Beers, W. G., M.D. 34 Beaver Hall-terrace, Montreal, Canada.
1873. ‡Behrens, Jacob. Springfield House, North-parade, Bradford, Yorkshire.
1874. ‡Belcher, Richard Boswell. Blockley, Worcestershire.
1891. *Belinfante, L. L., B.Sc., Assist.-Sec. G.S. Geological Society, Burlington House, London, W.
1892. ‡Bell, A. Beatson. 143 Princes-street, Edinburgh.
1873. ‡*Bell, Asahel P. 32 St. Anne's-street, Manchester.*
1871. ‡Bell, Charles B. 6 Spring-bank, Hull.
1884. ‡Bell, Charles Napier. Winnipeg, Canada.
1894. §BELL, F. JEFFREY, M.A., F.Z.S. 35 Cambridge-street, Hyde Park, London, W.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1860. ‡Bell, Rev. George Charles, M.A. Marlborough College, Wilts.
1862. *BELL, Sir ISAAC LOWTHIAN, Bart., LL.D., F.R.S., F.C.S., M.Inst.C.E. Rounton Grange, Northallerton.
1875. ‡BELL, JAMES, C.B., D.Sc., Ph.D., F.R.S., F.C.S. Howell Hill Lodge, Ewell, Surrey.
1891. ‡Bell, James. Bangor Villa, Clive-road, Cardiff.
1871. *BELL, J. CARTER, F.C.S. Bankfield, The Cliff, Higher Broughton, Manchester.
1883. *Bell, John Henry. Dalton Lees, Huddersfield.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1876. ‡Bell, R. Bruce, M.Inst.C.E. 203 St. Vincent-street, Glasgow.
1867. ‡Bell, Thomas. Belmont, Dundee.
1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.
1882. ‡*Bellingham, William. 15 Killieser-avenue, Telford Park, Streatham Hill, London, S.W.*
1893. ‡BELPER, The Right Hon. Lord, LL.M. Kingston, Nottinghamshire.
1884. ‡Bemrose, Joseph. 15 Plateau-street, Montreal, Canada.
1886. §§Benger, Frederick Baden, F.I.C., F.C.S. The Grange, Knutsford, Cheshire.
1885. ‡BENHAM, WILLIAM BLAXLAND, D.Sc. The Museum, Oxford.
1891. §Bennett, Alfred Rosling. 22 St. Alban's-road, Harlesden, London, N.W.

Year of
Election.

1870. ‡BENNETT, ALFRED W., M.A., B.Sc., F.L.S. 6 Park Village East, Regent's Park, London, N.W.
1836. ‡Bennett, Henry. Bedminster, Bristol.
1887. ‡*Bennett, James M. St. Mungo Chemical Company, Ruckhill, Glasgow.*
1881. §Bennett, John R. 16 West Park, Clifton, Bristol.
1883. *Bennett, Laurence Henry. Bedminster, Bristol.
1881. ‡Bennett, Rev. S. H., M.A. St. Mary's Vicarage, Bishopshill Junior, York.
1870. *Bennett, William. Oak Hill Park, Old Swan, near Liverpool.
1887. ‡Bennion, James A., M.A. 1 St. James'-square, Manchester.
1889. ‡Benson, John G. 12 Grey-street, Newcastle-upon-Tyne.
1848. ‡Benson, Starling. Gloucester-place, Swansea.
1887. *Benson, Mrs. W. J. Care of Standard Bank of South Africa, Stellenbosch, S. Africa.
1863. ‡Benson, William. Fourstones Court, Newcastle-upon-Tyne.
1885. *BENT, J. THEODORE. 13 Great Cumberland-place, London, W.
1884. ‡Bentham, William. 724 Sherbrooke-street, Montreal, Canada.
1894. §Berkeley, The Right Hon. the Earl of. The Heath, Boarshill, near Abingdon.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1886. ‡Bernard, W. Leigh. Calgary, Canada.
1894. §Berridge, Douglas. The Laboratory, The College, Malvern.
1870. ‡*Berwick George, M.D. 36 Fawcett-street, Sunderland.*
1862. ‡BESANT, WILLIAM HENRY, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1865. *BESSEMER, Sir HENRY, F.R.S. Denmark Hill, London, S.E.
1882. *Bessemer, Henry, jun. Town Hill Park, West End, Southampton.
1890. ‡Best, William Woodham. 31 Lyddon-terrace, Leeds.
1883. ‡*Bettany, Mrs. 33 Oakhurst-grove, East Dulwich-road, London, S.E.*
1880. *Bevan, Rev. James Oliver, M.A., F.G.S. 55 Gunterstone-road, London, W.
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1885. ‡Beveridge, R. Beath Villa, Ferryhill, Aberdeen.
1890. §Bevington, Miss Mary E. Merle Wood, Sevenoaks, Kent.
1863. ‡Bewick, Thomas John, F.G.S. Suffolk House, Laurence Pountney Hill, London, E.C.
1870. ‡Bickerton, A.W., F.C.S. Christchurch, Canterbury, New Zealand.
1888. *Bidder, George Parker. The Zoological Station, Naples.
1885. *BIDWELL, SHELFORD, M.A., LL.B., F.R.S. Riverstone Lodge, Southfields, Wandsworth, Surrey, S.W.
1882. §Biggs, C. H. W., F.C.S. Glebe Lodge, Champion Hill, London, S.E.
1891. ‡Billups, J. E. 29 The Parade, Cardiff.
1886. ‡Bindloss, G. F. Carnforth, Brondesbury Park, London, N.W.
1887. *Bindloss, James B. Elm Bank, Eccles, Manchester.
1884. *Bingham, Lieut.-Colonel John E., J.P. West Lea, Ranmoor, Sheffield.
1881. ‡Binnie, Alexander R., M.Inst.C.E., F.G.S. London County Council, Spring-gardens, London, S.W.
1873. ‡Binns, J. Arthur. Manningham, Bradford, Yorkshire.
1880. ‡Bird, Henry, F.C.S. South Down, near Devonport.
1888. *Birley, Miss Caroline. Seedley-terrace, Pendleton, Manchester.
1887. *Birley, H. K. 13 Hyde-road, Ardwick, Manchester.
1871. *BISCHOF, GUSTAV. 4 Hart-street, Bloomsbury, London, W.C.
1892. ‡Bishop, Arthur W., Ph.D. Heriot Watt College, Edinburgh.

Year of
Election.

1883. ‡Bishop, John le Marchant. 100 Mosley-street, Manchester.
1894. §Bisset, James. 5 East India-avenue, London, E.C.
1885. ‡Bissett, J. P. Wyndem, Banchory, N.B.
1886. *Bixby, Captain W. H. War Department, Washington, U.S.A.
1889. ‡Black, W. 1 Lovaine-place, Newcastle-upon-Tyne.
1889. ‡Black, William. 12 Romulus-terrace, Gateshead.
1881. ‡Black, Surgeon-Major William Galt, F.R.C.S.E. Caledonian United Service Club, Edinburgh.
1869. ‡Blackall, Thomas. 13 Southernhay, Exeter.
1834. Blackburn, Bewicke. Calverley Park, Tunbridge Wells.
1876. ‡Blackburn, Hugh, M.A. Roshven, Fort William, N.B.
1884. ‡Blackburn, Robert. New Edinburgh, Ontario, Canada.
1877. ‡Blackie, J. Alexander. 17 Stanhope-street, Glasgow.
1876. ‡Blackie, Robert. 7 Great Western-terrace, Glasgow.
1855. *Blackie, W. G., Ph.D., F.R.G.S. 17 Stanhope-street, Glasgow.
1884. ‡Blacklock, Frederick W. 25 St. Famille-street, Montreal, Canada.
1883. ‡Blacklock, Mrs. Sea View, Lord-street, Southport.
1895. §Blaikie, W. B. 6 Belgrave-crescent, Edinburgh.
1888. ‡Blaine, R. S., J.P. Summerhill Park, Bath.
1883. ‡Blair, Mrs. Oakshaw, Paisley.
1892. ‡Blair, Alexander. 35 Moray-place, Edinburgh.
1892. ‡Blair, John. 9 Ettrick-road, Edinburgh.
1863. ‡Blake, C. Carter, D.Sc. 6 St. Edmund's-terrace, St. John's Wood, London, N.W.
1886. ‡Blake, Dr. James. San Francisco, California.
1849. *Blake, Henry Wollaston, M.A., F.R.S., F.R.G.S. 8 Devonshire-place, Portland-place, London, W.
1883. *Blake, Rev. J. F., M.A., F.G.S. 43 Clifton Hill, London, N.W.
1846. *Blake, William. Bridge House, South Petherton, Somerset.
1891. ‡Blakesley, Thomas H., M.A., M.Inst.C.E. Royal Naval College, Greenwich, London, S.E.
1886. ‡Blakie, John. The Bridge House, Newcastle, Staffordshire.
1894. §§Blakiston, Rev. C. D. Exwick Vicarage, Exeter.
1887. ‡Blamires, George. Cleckheaton.
1881. §Blamires, Thomas H. Close Hill, Lockwood, near Huddersfield.
1895. §Blamires, William. Oak House, Taylor Hill, Huddersfield.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1869. ‡Blanford, W. T., LL.D., F.R.S., F.G.S., F.R.G.S. 72 Bedford-gardens, Campden Hill, London, W.
1887. *Bles, A. J. S. Cambridge.
1887. *Bles, Edward J. 12 King's-parade, Cambridge.
1887. ‡Bles, Marcus S. The Beeches, Broughton Park, Manchester.
1884. *Blish, William G. Niles, Michigan, U.S.A.
1880. ‡Bloxam, G. W., M.A. 11 Presburg-street, Clapton, London, N.E.
1888. §Bloxsom, Martin, B.A., Assoc.M.Inst.C.E. Hazelwood, Crumpsall Green, Manchester.
1870. ‡Blundell, Thomas Weld. Ince Blundell Hall, Great Crosby, Lancashire.
1859. ‡Blunt, Captain Richard. Bretlands, Chertsey, Surrey.
1885. ‡Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College, Glasgow.
Blyth, B. Hall. 135 George-street, Edinburgh.
1883. ‡Blyth, Miss Phœbe. 27 Mansion House-road, Edinburgh.
1867. *Blyth-Martin, W. Y. Blyth House, Newport, Fife.
1887. ‡Blythe, William S. 65 Mosley-street, Manchester.
1870. ‡Boardman, Edward. Oak House, Eaton, Norwich.
1887. *Boddington, Henry Pownall Hall, Wilmslow, Manchester.

Year of Election.

1889. ‡Bodmer, G. R., Assoc.M.Inst.C.E. 30 Walbrook, London, E.C.
1884. ‡Body, Rev. C. W. E., M.A. Trinity College, Toronto, Canada.
1887. *Boissevain, Gideon Maria. 4 Tesselschade-straat, Amsterdam.
1881. ‡Bojanowski, Dr. Victor de. 27 Finsbury-circus, London, E.C.
1876. ‡Bolton, J. C. Carbrook, Stirling.
1894. §Bolton, John. Clifton-road, Crouch End, London, N.
1883. §Bonney, Frederic, F.R.G.S. Colton House, Rugeley, Staffordshire.
1883. §Bonney, Miss S. 23 Denning-road, Hampstead, London, N.W.
1871. *Bonney, Rev. Thomas George, D.Sc., LL.D., F.R.S., F.S.A., F.G.S., Professor of Geology in University College, London. 23 Denning-road, Hampstead, London, N.W.
1866. ‡Booker, W. H. Cromwell-terrace, Nottingham.
1888. ‡Boon, William. Coventry.
1893. §Boot, Jesse. Carlyle House, 18 Burns-street, Nottingham.
1890. *Booth, Charles, F.S.S. 2 Talbot-court, Gracechurch-street, London, E.C.
1883. §Booth, James. Hazelhurst, Turton.
1883. ‡Booth, Richard. 4 Stone-buildings, Lincoln's Inn, London, W.C.
1876. ‡Booth, Rev. William H. Mount Nod-road, Streatham, London, S.W.
1883. ‡Boothroyd, Benjamin. Solihull, Birmingham.
1876. *Borland, William. 260 West George-street, Glasgow.
1882. §Borns, Henry, Ph.D., F.C.S. 19 Alexandra-road, Wimbledon, Surrey.
1876. *Bosanquet, R. H. M., M.A., F.R.S., F.R.A.S., F.C.S. New University Club, St. James's-street, London, S.W.
*Bossey, Francis, M.D. Mayfield, Oxford-road, Redhill, Surrey.
1881. §Bothamley, Charles H., F.I.C., F.C.S., Director of Technical Instruction, Somerset County Education Committee. Wentworth, Weston-super-Mare.
1887. ‡Bott, Dr. Owens College, Manchester.
1872. ‡Bottle, Alexander. Dover.
1868. ‡Bottle, J. T. 28 Nelson-road, Great Yarmouth.
1887. ‡Bottomley, James, D.Sc., B.A. 220 Lower Broughton-road, Manchester.
1871. *Bottomley, James Thomson, M.A., F.R.S., F.R.S.E., F.C.S. The University, Glasgow.
1884. *Bottomley, Mrs. The University, Glasgow.
1892. ‡Bottomley, W. B. Ferncliffe, Morecambe.
1876. ‡*Bottomley, William, jun. 6 Rokeley-terrace, Hillhead, Glasgow.*
1890. §Boulnois, Henry Percy, M.Inst.C.E. Municipal Offices, Liverpool.
1883. ‡Bourdas, Isaiah. Dunoon House, Clapham Common, London, S.W.
1883. ‡Bourne, A. G., D.Sc., F.R.S., F.L.S., Professor of Zoology in the Presidency College, Madras.
1893. §Bourne, G. C., M.A., F.L.S. New College, Oxford.
1889. ‡Bourne, R. H. Fox. 41 Priory-road, Bedford Park, Chiswick.
1866. §Bourne, Stephen, F.S.S. 5 Lansdown-road, Lee, S.E.
1890. ‡Bousfield, C. E. 55 Clarendon-road, Leeds.
1884. ‡Bovey, Henry T., M.A., Professor of Civil Engineering and Applied Mechanics in McGill University, Montreal. Ontario-avenue, Montreal, Canada.
1888. ‡Bowden, Rev. G. New Kingswood School, Lansdown, Bath.
1881. *Bower, F. O., D.Sc., F.R.S., F.L.S., Regius Professor of Botany in the University of Glasgow.
1856. *Bowlby, Miss F. E. 23 Lansdowne-parade, Cheltenham.
1886. ‡Bowlby, Rev. Canon. 101 Newhall-street, Birmingham.
1884. ‡*Bowley, Edwin. Burnt Ash Hill, Lee, Kent.*

Year of Election.

1880. ‡Bowly, Christopher. Cirencester.
1887. ‡Bowly, Mrs. Christopher. Cirencester.
1865. §Bowman, F. H., D.Sc., F.R.S.E., F.L.S. Mayfield, Knutsford, Cheshire.
1887. §Box, Alfred M. 68 Huntingdon-road, Cambridge.
1895. *Boyce, Rubert. University College, Liverpool.
1884. *Boyd, M. A., M.D. 30 Merrion-square, Dublin.
1871. ‡Boyd, Thomas J. 41 Moray-place, Edinburgh.
1865. ‡BOYLE, The Very Rev. G. D., M.A., Dean of Salisbury. The Deanery, Salisbury.
1884. *Boyle, R. Vicars, C.S.I. Care of Messrs. Grindlay & Co., 55 Parliament-street, London, S.W.
1892. §§BOYS, CHARLES VERNON, F.R.S., Assistant Professor of Physics in the Royal College of Science, London, S.W.
1872. *BRABROOK, E. W., F.S.A. 178 Bedford-hill, Balham, London, S.W.
1869. *Braby, Frederick, F.G.S., F.C.S. Bushey Lodge, Teddington, Middlesex.
1894. *Braby, Ivon. Bushey Lodge, Teddington, Middlesex.
1893. §Bradley, F. L. Bel Air, Alderley Edge, Cheshire.
1892. §Bradshaw, W. Carisbrooke House, The Park, Nottingham.
1857. *Brady, Cheyne, M.R.I.A. Trinity Vicarage, West Bromwich.
1863. ‡BRADY, GEORGE S., M.D., LL.D., F.R.S., F.L.S., Professor of Natural History in the Durham College of Science, Newcastle-on-Tyne. 2 Mowbray-villas, Sunderland.
1880. *Brady, Rev. Nicholas, M.A. Rainham Hall, Rainham, Romford, Essex.
1864. ‡BRAHAM, PHILIP, F.C.S. 3 Cobden-mansions, Stockwell-road, London, S.E.
1870. ‡Braidwood, Dr. 35 Park-road South, Birkenhead.
1888. §Braikenridge, W. J., J.P. 16 Royal-crescent, Bath.
1879. ‡Bramley, Herbert. 6 Paradise-square, Sheffield.
1865. §BRAMWELL, Sir FREDERICK J., Bart., D.C.L., LL.D., F.R.S., M.Inst.C.E. 5 Great George-street, London, S.W.
1872. ‡Bramwell, William J. 17 Prince Albert-street, Brighton.
1867. ‡Brand, William. Milnefield, Dundee.
1861. *Brandreth, Rev. Henry. The Rectory, Dickleburgh.
1885. *Bratby, William, J.P. Oakfield Hale, Altrincham, Cheshire.
1890. *Bray, George. Belmont, Headingley, Leeds.
1868. ‡Bremridge, Elias. 17 Bloomsbury-square, London, W.C.
1877. ‡Brent, Francis. 19 Clarendon-place, Plymouth.
1882. *Bretherton, C. E. Goldsmith-buildings, Temple, London, E.C.
1881. *Brett, Alfred Thomas, M.D. Watford House, Watford.
1866. ‡Brettell, Thomas (Mine Agent). Dudley.
1875. ‡*Briant, T. Hampton Wick, Kingston-on-Thames.*
1886. §§Bridge, T. W., M.A., Professor of Zoology in the Mason Science College, Birmingham.
1870. *Bridson, Joseph R. Sawrey, Windermere.
1887. ‡Brierley, John, J.P. The Clough, Whitefield, Manchester.
1870. ‡Brierley, Joseph. New Market-street, Blackburn.
1886. ‡Brierley, Leonard. Somerset-road, Edgbaston, Birmingham.
1879. ‡Brierley, Morgan. Denshaw House, Saddleworth.
1870. *BRIGG, JOHN. Broomfield, Keighley, Yorkshire.
1890. ‡Brigg, W. A. Kildwick Hall, near Keighley, Yorkshire.
1893. ‡Bright, Joseph. Western-terrace, The Park, Nottingham.
1868. ‡Brine, Admiral Lindesay, F.R.G.S. United Service Club, Pall Mall, London, S.W.
1893. §§Briscoe, Albert E., A.R.C.Sc., B.Sc. University College, Nottingham.

Year of
Election.

1884. ‡Brisette, M. H. 424 St. Paul-street, Montreal, Canada.
1879. ‡*Brittain, Frederick. Taptonville-crescent, Sheffield.*
1879. *BRITTAIN, W. H., J.P., F.R.G.S. Storth Oaks, Ranmoor, Sheffield.
1878. ‡Britten, James, F.L.S. Department of Botany, British Museum, London, S.W.
1884. *Brittle, John R., M.Inst.C.E., F.R.S.E. Farad Villa, Vanbrugh Hill, Blackheath, London, S.E.
1859. *BRODHURST, BERNARD EDWARD, F.R.C.S. 20 Grosvenor-street, Grosvenor-square, London, W.
1883. *Brodie, David, M.D. 12 Patten-road, Wandsworth Common, S.W.
1865. ‡BRODIE, Rev. PETER BELLINGER, M.A., F.G.S. Rowington Vicarage, near Warwick.
1884. ‡Brodie, William, M.D. 64 Lafayette-avenue, Detroit, Michigan, U.S.A.
1883. *Brodie-Hall, Miss W. L. The Gore, Eastbourne.
1881. §Brook, Robert G. Raven-street, St. Helens, Lancashire.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Ven. Archdeacon J. Ingham. The Vicarage, Halifax.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1888. ‡Brooke, Rev. Canon R. E., M.A. 14 Marlborough-buildings, Bath.
1887. §Brooks, James Howard. Elm Hirst, Wilmslow, near Manchester.
1863. ‡Brooks, John Crosse. 14 Lovaine-place, Newcastle-on-Tyne.
1887. ‡Brooks, S. H. Slade House, Levenshulme, Manchester.
1887. *Bros, W. Law. Sidcup, Kent.
1883.§§Brotherton, E. A. Fern Cliffe, Ilkley, Yorkshire.
1883. *Brough, Mrs. Charles S. Rosendale Hall, West Dulwich, London, S.E.
1886. §Brough, Professor Joseph, LL.M., Professor of Logic and Philosophy in University College, Aberystwith.
1885. *Browett, Alfred. 14 Dean-street, Birmingham.
1863. *BROWN, ALEXANDER CRUM, M.D., LL.D., F.R.S., F.R.S.E., F.C.S., Professor of Chemistry in the University of Edinburgh. 8 Belgrave-crescent, Edinburgh.
1892. ‡Brown, Andrew, M.Inst.C.E. Messrs. Wm. Simons & Co., Renfrew, near Glasgow.
1867. ‡Brown, Charles Gage, M.D., C.M.G. 88 Sloane-street, London, S.W.
1855. ‡Brown, Colin. 192 Hope-street, Glasgow.
1871. ‡Brown, David. Willowbrae House, Midlothian.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1883. ‡Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1881. ‡Brown, Frederick D. 26 St. Giles's-street, Oxford.
1883. ‡Brown, George Dransfield. Henley Villa, Ealing, Middlesex, W.
1884. ‡Brown, Gerald Culmer. Lachute, Quebec, Canada.
1883. ‡Brown, Mrs. H. Bienz. 26 Ferryhill-place, Aberdeen.
1883. ‡Brown, Mrs. Helen. Canaan-grove, Newbattle-terrace, Edinburgh.
1870. §BROWN, HORACE T., F.R.S., F.C.S., F.G.S. 52 Nevern-square, London, S.W.
Brown, Hugh. Broadstone, Ayrshire.
1883. ‡Brown, Miss Isabella Spring. Canaan-grove, Newbattle-terrace, Edinburgh.
1895. §BROWN, J. ALLEN, J.P., F.R.G.S., F.G.S. 7 Kent-gardens, Ealing, London, W.
1870. *BROWN, Professor J. CAMPBELL, D.Sc., F.C.S. University College, Liverpool.
1876. §Brown, John. Edenderry House, Newtownbreda, Belfast.

Year of Election.

1881. *Brown, John, M.D. 68 Bank-parade, Burnley, Lancashire.
1882. *Brown, John. 7 Second-avenue, Sherwood Rise, Nottingham.
1895. *Brown, John Charles. 7 Second-avenue, Nottingham.
1859. ‡Brown, Rev. John Crombie, LL.D. Haddington, N.B.
1894.§§Brown, J. H. 6 Cambridge-road, Brighton.
1882. *Brown, Mrs. Mary. 68 Bank-parade, Burnley, Lancashire.
1886. §Brown, R., R.N. Laurel Bank, Barnhill, Perth.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-upon-Tyne.
1871. ‡BROWN, ROBERT, M.A., Ph.D., F.L.S., F.R.G.S. Fersley, Rydal-road, Streatham, London, S.W.
1891. §BROWN, T. FORSTER, M.Inst.C.E., F.G.S. Guildhall Chambers, Cardiff.
1865. ‡Brown, William. 41A New-street, Birmingham.
1885. ‡Brown, W. A. The Court House, Aberdeen.
1884. ‡Brown, William George. Ivy, Albemarle Co., Virginia, U.S.A.
1863. ‡Browne, Sir Benjamin Chapman, M.Inst.C.E. Westacres, Newcastle-upon-Tyne.
1892. ‡Browne, Harold Crichton. Crindon, Dumfries.
1895. *Browne, Henry Taylor. 10 Hyde Park-terrace, London, W.
1879. ‡BROWNE, Sir J. CRICHTON, M.D., LL.D., F.R.S., F.R.S.E. 61 Carlisle-street-mansions, Victoria-street, London, S.W.
1891. §BROWNE, MONTAGU, F.G.S. Town Museum, Leicester.
1862. *Browne, Robert Clayton, M.A. Sandbrook, Tullow, Co. Carlow, Ireland.
1872. ‡Browne, R. Mackley, F.G.S. Redcot, Bradbourne, Sevenoaks, Kent.
1887. ‡Brownell, T. W. 6 St. James's-square, Manchester.
1865. ‡Browning, John, F.R.A.S. 63 Strand, London, W.C.
1883. ‡Browning, Oscar, M.A. King's College, Cambridge.
1855. ‡Brownlee, James, jun. 30 Burnbank-gardens, Glasgow.
1892. ‡Bruce, James. 10 Hill-street, Edinburgh.
1893. §Bruce, William S. University Hall, Riddle's-court, Edinburgh.
1863. *Brunel, H. M., M.Inst.C.E. 21 Delahay-street, Westminster, S.W.
1863. ‡Brunel, J. 21 Delahay-street, Westminster, S.W.
1875. ‡Brunlees, John. 5 Victoria-street, Westminster, S.W.
1868. ‡BRUNTON, T. LAUDER, M.D., D.Sc., F.R.S. 10 Stratford-place, Oxford-street, London, W.
1891. ‡*Bruton, Edward Henry.* 181 *Richmond-road, Cardiff.*
1878. §Brutton, Joseph. Yeovil.
1886. *BRYAN, G. H., F.R.S. Thornlea, Trumpington-road, Cambridge.
1894. §Bryan, Mrs. R. P. Thornlea, Trumpington-road, Cambridge.
1884. ‡Bryce, Rev. Professor George. The College, Manitoba, Canada.
1894. §Brydone, R. M. Petworth, Sussex.
1890. §Bubb, Henry. Ullenwood, near Cheltenham.
1871. §BUCHAN, ALEXANDER, M.A., LL.D., F.R.S.E., Sec. Scottish Meteorological Society. 42 Heriot-row, Edinburgh.
1867. ‡Buchan, Thomas. Strawberry Bank, Dundee.
1885. *Buchan, William Paton. Fairyknowe, Cambuslang, N.B.
1881. *Buchanan, John H., M.D. Sowerby, Thirsk.
1871. ‡BUCHANAN, JOHN YOUNG, M.A., F.R.S., F.R.S.E., F.R.G.S., F.C.S. 10 Moray-place, Edinburgh.
1884. ‡Buchanan, W. Frederick. Winnipeg, Canada.
1883. ‡Buckland, Miss A. W. 5 Beaumont-crescent, West Kensington, London, W.
1886. *Buckle, Edmund W. 23 Bedford-row, London, W.C.
1864. ‡BUCKLE, Rev. GEORGE, M.A. Wells, Somerset.
1865. *Buckley, Henry. 8 St. Mary's-road, Leamington.
1886. §Buckley, Samuel. Merlewood, Beaver Park, Didsbury.

Year of
Election.

1884. *Buckmaster, Charles Alexander, M.A., F.C.S. 16 Heathfield-road, Mill Hill Park, London, W.
1880. ‡Buckney, Thomas, F.R.A.S. 53 Gower-street, London, W.C.
1869. ‡Bucknill, Sir J. C., M.D., F.R.S. East Cliff House, Bournemouth.
1851. *Buckton, George Bowdler, F.R.S., F.L.S., F.C.S. Weycombe, Haslemere, Surrey.
1887. ‡Budenberg, C. F., B.Sc. Buckau Villa, Demesne-road, Whalley Range, Manchester.
1875. ‡Budgett, Samuel. Kirton, Albemarle-road, Beckenham, Kent.
1883. ‡Buick, Rev. George R., M.A. Cullybackey, Co. Antrim, Ireland.
1893. §Bulleid, Arthur. Glastonbury.
1871. ‡Bulloch, Matthew. 48 Prince's-gate, London, S.W.
1881. ‡Bulmer, T. P. Mount-villas, York.
1883. ‡Bulpit, Rev. F. W. Crossens Rectory, Southport.
1865. ‡Bunce, John Thackray. 'Journal' Office, New-street, Birmingham.
1895. §Bunte, Dr. Hans. Karlsruhe, Baden.
1886. §§Burbury, S. H., M.A., F.R.S. 1 New-square, Lincoln's Inn, London, W.C.
1842. *Burd, John. Glen Lodge, Knocknerea, Sligo.
1875. ‡Burder, John, M.D. 7 South-parade, Bristol.
1869. ‡Burdett-Coutts, Baroness. 1 Stratton-street, Piccadilly, London, W.
1881. ‡Burdett-Coutts, W. L. A. B., M.P. 1 Stratton-street, Piccadilly, London, W.
1891. ‡Burge, Very Rev. T. A. Ampleforth Cottage, near York.
1894. §Burke, John. 77 Pembroke-road, Dublin.
1884. *Burland, Lieut.-Col. Jeffrey H. 287 University-street, Montreal, Canada.
1888. ‡Burne, H. Holland. 28 Marlborough-buildings, Bath.
1883. *Burne, Major-General Sir Owen Tudor, K.C.S.I., C.I.E., F.R.G.S. 132 Sutherland-gardens, Maida Vale, London, W.
1876. ‡Burnet, John. 14 Victoria-crescent, Dowanhill, Glasgow.
1885. *Burnett, W. Kendall, M.A. 11 Belmont-street, Aberdeen.
1877. ‡Burns, David. Alston, Carlisle.
1884. ‡Burns, Professor James Austin. Southern Medical College, Atlanta, Georgia, U.S.A.
1883. ‡Burr, Percy J. 20 Little Britain, London, E.C.
1887. ‡Burroughs, Eggleston, M.D. Snow Hill-buildings, London, E.C.
1883. *Burrows, Abraham. Russell House, Rhyl, North Wales.
1860. ‡Burrows, Montague, M.A., Professor of Modern History, Oxford.
1894. §§Burstall, H. F. W. 76 King's-road, Camden-road, London, N.W.
1891. ‡Burt, J. J. 103 Roath-road, Cardiff.
1888. ‡Burt, John Mowlem. 3 St. John's-gardens, Kensington, London, W.
1888. ‡Burt, Mrs. 3 St. John's-gardens, Kensington, London, W.
1894. §Burton, Charles V. 24 Wimpole-street, London, W.
1866. *Burton, Frederick M., F.L.S., F.G.S. Highfield, Gainsborough.
1889. ‡Burton, Rev. R. Lingen. Little Aston, Sutton Coldfield.
1892. ‡Burton-Brown, Colonel Alexander, R.A., F.R.A.S., F.G.S. St. George's Club, Hanover-square, London, W.
1887. *Bury, Henry. Trinity College, Cambridge.
1895. §Bushe, Colonel C. K. Bramhope, Old Charlton, Kent.
1878. ‡Butcher, J. G., M.A. 22 Collingham-place, London, S.W.
1884. *Butcher, William Deane, M.R.C.S.Eng. Clydesdale, Windsor.
1884. ‡Butler, Matthew I. Napanee, Ontario, Canada.
1888. ‡Buttanshaw, Rev. John. 22 St. James's-square, Bath.
1884. *Butterworth, W. Greenhill, Church-lane, Harpurhey, Manchester.
1872. ‡Buxton, Charles Louis. Cromer, Norfolk.
1883. ‡Buxton, Miss F. M. Newnham College, Cambridge.

Year of Election.

1887. *Buxton, J. H. Clumber Cottage, Montague-road, Felixstowe.
1868. ‡Buxton, S. Gurney. Catton Hall, Norwich.
1881. ‡Buxton, Sydney. 15 Eaton-place, London, S.W.
1872. ‡Buxton, Sir Thomas Fowell, Bart., K.C.M.G., F.R.G.S. Warlies, Waltham Abbey, Essex.
1854. ‡BYERLEY, ISAAC, F.L.S. 22 Dingle-lane, Toxteth-park, Liverpool.
1885. ‡Byres, David. 63 North Bradford, Aberdeen.
1852. ‡Byrne, Very Rev. James. Ergenagh Rectory, Omagh.
1883. ‡Byrom, John R. Mere Bank, Fairfield, near Manchester.

1889. ‡Cackett, James Thoburn. 60 Larkspur-terrace, Newcastle-upon-Tyne.
1892. ‡Cadell, Henry M., B.Sc., F.R.S.E. Grange, Bo'ness, N.B.
1863. ‡Cail, Richard. Beaconsfield, Gateshead.
1894. §§Caillard, Miss E. M. Wingfield House, near Trowbridge, Wilts.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. 8 Magdalene-road, Dundee.
1875. ‡Caldicott, Rev. J. W., D.D. The Rectory, Shipston-on-Stour.
1886. *Caldwell, William Hay. Cambridge.
1868. ‡Caley, A. J. Norwich.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1887. ‡CALLAWAY CHARLES, M.A., D.Sc., F.G.S. Sandon, Wellington, Shropshire.
1892. ‡Calvert, A. F., F.R.G.S. The Mount, Oseney-crescent, Camden-road, London, N.
1884. ‡Cameron, Æneas. Yarmouth, Nova Scotia, Canada.
1876. ‡Cameron, Sir Charles, Bart., M.D., LL.D., M.P. 1 Huntly-gardens, Glasgow.
1857. ‡CAMERON, Sir CHARLES A., M.D. 15 Pembroke-road, Dublin.
1884. ‡Cameron, James C., M.D. 41 Belmont-park, Montreal, Canada.
1870. ‡Cameron, John, M.D. 17 Rodney-street, Liverpool.
1884. ‡Campbell, Archibald H. Toronto, Canada.
1883. ‡*Campbell, H. J.* 81 *Kirkstall-road, Talfourd Park, Streatham Hill, London, S.W.*
1876. ‡Campbell, James A., LL.D., M.P. Stracathro House, Brechin.
Campbell, John Archibald, M.D., F.R.S.E. Albyn-place, Edinburgh.
1862. *CAMPION, Rev. WILLIAM M., D.D. Queen's College, Cambridge.
1882. ‡Candy, F. H. 71 High-street, Southampton.
1890. ‡Cannan, Edwin, M.A., F.S.S. 24 St. Giles's, Oxford.
1888. ‡Cappel, Sir Albert J. L., K.C.I.E. 27 Kensington Court-gardens, London, W.
1894. §Capper, D. S., M.A., Professor of Mechanical Engineering in King's College, London, W.C.
1880. ‡Capper, Robert. 18 Parliament-street, Westminster, S.W.
1883. ‡Capper, Mrs. R. 18 Parliament-street, Westminster, S.W.
1887. ‡Capstick, John Walton. University College, Dundee.
1873. *CARBUTT, Sir EDWARD HAMER, Bart., M.Inst.C.E. 19 Hyde Park-gardens, London, W.
1877. ‡Carkeet, John. 3 St. Andrew's-place, Plymouth.
1867. ‡Carmichael, David (Engineer). Dundee.
1876. ‡*Carmichael, Neil, M.D.* 22 *South Cumberland-street, Glasgow.*
1884. ‡Carnegie, John. Peterborough, Ontario, Canada.
1884. ‡Carpenter, Louis G. Agricultural College, Fort Collins, Colorado, U.S.A.
1854. ‡Carpenter, Rev. R. Lant, B.A. Bridport.
1889. ‡Carr, Cuthbert Ellison. Hedgeley, Alnwick.
1893. ‡Carr, J. Wesley, M.A., F.G.S. 128 Mansfield-road, Nottingham.

Year of Election.

1889. ‡Carr-Ellison, John Ralph. Hedgeley, Alnwick.
1867. ‡CARRUTHERS, WILLIAM, F.R.S., F.L.S., F.G.S. British Museum, London, S.W.
1886. ‡CARSLAKE, J. BARHAM. 30 Westfield-road, Birmingham.
1883. ‡Carson, John. 51 Royal Avenue, Belfast.
1861. *Carson, Rev. Joseph, D.D., M.R.I.A. 18 Fitzwilliam-place, Dublin.
1868. ‡Carteighe, Michael, F.C.S. 172 New Bond-street, London, W.
1866. ‡Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, F.G.S. Cockerham Hall, Barnsley, Yorkshire.
1870. ‡Carter, Dr. William. 78 Rodney-street, Liverpool.
1883. ‡Carter, W. C. Manchester and Salford Bank, Southport.
1883. ‡Carter, Mrs. Manchester and Salford Bank, Southport.
1878. *Cartwright, Ernest H., M.A., M.D. 1 Courtfield-gardens, London, S.W.
1870. §Cartwright, Joshua, M.Inst.C.E., F.S.I., Borough and Water Engineer. Bury, Lancashire.
1862. ‡Carulla, F. J. R. 84 Argyll-terrace, Derby.
1884. *Carver, Rev. Canon Alfred J., D.D., F.R.G.S. Lynnhurst, Streatham Common, London, S.W.
1884. ‡Carver, Mrs. Lynnhurst, Streatham Common, London, S.W.
1883. ‡*Carver, James. Garfield House, Elm-avenue, Nottingham.*
1887. ‡Casartelli, Rev. L. C., M.A., Ph.D. St. Bede's College, Manchester.
1866. ‡Casella, L. P., F.R.A.S. The Lawns, Highgate, London, N.
1871. ‡Cash, Joseph. Bird-grove, Coventry.
1873. *Cash, William, F.G.S. 38 Elmfield-terrace, Savile Park, Halifax.
1888. ‡Cater, R. B. Avondale, Henrietta Park, Bath.
1874. ‡Caton, Richard, M.D. Lea Hall, Gateacre, Liverpool.
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1886. *Cave-Moyles, Mrs. Isabella. Repton Lodge, Harborne, Birmingham.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1871. *Cecil, Lord Sackville. Hayes Common, Beckenham, Kent.
1883. ‡Chadwick, James Percy. 51 Alexandra-road, Southport.
1859. ‡*Chadwick, Robert. Highbank, Manchester.*
1883. ‡Chalk, William. 24 Gloucester-road, Birkdale, Southport.
1859. ‡Chalmers, John Inglis. Aldbar, Aberdeen.
1883. ‡Chamberlain, George, J.P. Helensholme, Birkdale Park, Southport.
1884. ‡Chamberlain, Montague. St. John, New Brunswick, Canada.
1883. ‡CHAMBERS, CHARLES, F.R.S. Colába Observatory, Bombay.
1883. ‡Chambers, Mrs. Colába Observatory, Bombay.
1883. ‡Chambers, Charles, jun., Assoc.M.Inst.C.E. Colába Observatory, Bombay.
*Champney, Henry Nelson. 4 New-street, York.
1881. **Champney, John E. Woodlands, Halifax.*
1865. ‡Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James T. 1 Grand Avenue, Brighton.
1886. *Chance, John Horner. 40 Augustus-road, Edgbaston, Birmingham.
1865. ‡Chance, Robert Lucas. Chad Hill, Edgbaston, Birmingham.
1888. ‡Chandler, S. Whitty, B.A. Sherborne, Dorset.
1861. *Chapman, Edward, M.A., F.L.S., F.C.S. Hill End, Mottram, Manchester.
1889. ‡Chapman, L. H. 147 Park-road, Newcastle-upon-Tyne.
1884. ‡Chapman, Professor. University College, Toronto, Canada.
1877. ‡Chapman, T. Algernon, M.D. Firbank, Hereford.

Year of
Election.

1874. ‡Charles, J. J., M.D., Professor of Anatomy and Physiology in Queen's College, Cork. Newmarket, Co. Cork.
1874. ‡Charley, William. Seymour Hill, Dunmurry, Ireland.
1866. ‡CHARNOCK, RICHARD STEPHEN, Ph.D., F.S.A. Crichton Club, Adelphi-terrace, London, W.C.
1886. ‡Chate, Robert W. Southfield, Edgbaston, Birmingham.
1883. ‡*Chater, Rev. John. Part-street, Southport.*
1884. *Chatterton, George, M.A., M.Inst.C.E. 46 Queen Anne's-gate, London, S.W.
1886. §Chattock, A.P. University College, Bristol.
1867. *Chatwood, Samuel, F.R.G.S. High Lawn, Broad Oak Park, Worsley, Manchester.
1884. ‡CHAUVEAU, The Hon. Dr. Montreal, Canada.
1883. ‡Chawner, W., M.A. Emmanuel College, Cambridge.
1864. ‡CHEADLE, W. B., M.A., M.D., F.R.G.S. 2 Hyde Park-place, Cumberland-gate, London, S.W.
1887. ‡Cheetham, F. W. Limefield House, Hyde.
1887. ‡Cheetham, John. Limefield House, Hyde.
1874. *Chermside, Lieut.-Colonel H. C., R.E., C.B. Care of Messrs. Cox & Co., Craig's-court, Charing Cross, London, S.W.
1884. ‡Cherriman, Professor J. B. Ottawa, Canada.
1879. *Chesterman, W. Belmayne, Sheffield.
1865. *Child, Gilbert W., M.A., M.D., F.L.S. Holywell Lodge, Oxford.
1883. ‡Chinery, Edward F. Monmouth House, Lymington.
1884. ‡Chipman, W. W. L. 6 Place d'Armes, Ontario, Canada.
1889. ‡Chirney, J. W. Morpeth.
1894. §§Chisholm, G. C., M.A., B.Sc. 26 Dornton-road, Balham, London, S.W.
1842. *Chiswell, Thomas. 17 Lincoln-grove, Plymouth-grove, Manchester.
1863. ‡Cholmeley, Rev. C. H. The Rectory, Beaconsfield R.S.O., Buckinghamshire.
1882. ‡Chorley, George. Midhurst, Sussex.
1887. ‡Chorlton, J. Clayton. New Holme, Withington, Manchester.
1893. *CHREE, CHARLES, D.Sc. Superintendent of the Kew Observatory, Richmond, Surrey.
1861. ‡*Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.*
1884. *Christie, William. Duke-street, Toronto, Canada.
1875. *Christopher, George, F.C.S. 6 Barrow-road, Streatham Common, London, S.W.
1876. *CHRYSTAL, GEORGE, M.A., LL.D., F.R.S.E., Professor of Mathematics in the University of Edinburgh. 5 Belgrave-crescent, Edinburgh.
1870. §CHURCH, A. H., M.A., F.R.S., F.C.S., Professor of Chemistry to the Royal Academy of Arts, London. Shelsley, Ennerdale-road, Kew, Surrey.
1860. ‡Church, William Selby, M.A. St. Bartholomew's Hospital, London, E.C.
1857. ‡Churchill, F., M.D. Ardtrea Rectory, Stewartstown, Co. Tyrone.
1857. ‡*Clarendon, Frederick Villiers.* 1 *Belvidere-place, Mountjoy-square, Dublin.*
1876. ‡*Clark, David R., M.A.* 31 *Waterloo-street, Glasgow.*
1890. ‡*Clark, E. K.* 81 *Caledonian-road, Leeds.*
1877. *Clark, F. J., J.P., F.L.S. Street, Somerset.
Clark, George T. 44 Berkeley-square, London, W.
1876. ‡Clark, George W. 31 Waterloo-street, Glasgow.
1892. §Clark, James, M.A., Ph.D. Yorkshire College, Leeds.
1892. ‡Clark, James. Chapel House, Paisley.
1876. ‡Clark, Dr. John. 138 Bath-street, Glasgow.

Year of Election.

1881. ‡Clark, J. Edmund, B.A., B.Sc., F.G.S. 12 Feversham-terrace, York.
1861. ‡CLARK, LATIMER, F.R.S., F.R.A.S., M.Inst.C.E. 11 Victoria-street, London, S.W.
1855. ‡Clark, Rev. William, M.A. Barrhead, near Glasgow.
1883. ‡Clarke, Rev. Canon, D.D. 59 Hoghton-street, Southport.
1887. §Clarke, C. Goddard. Ingleside, Elm-grove, Peckham, S.E.
1875. ‡Clarke, Charles S. 4 Worcester-terrace, Clifton, Bristol.
1886. ‡Clarke, David. Langley-road, Small Heath, Birmingham.
1886. §Clarke, Rev. H. J. Great Barr Vicarage, Birmingham.
1875. ‡CLARKE, JOHN HENRY. 4 Worcester-terrace, Clifton, Bristol.
1861. **Clarke, John Hope. 62 Nelson-street, Chorlton-on-Medlock, Manchester.*
1877. ‡Clarke, Professor John W. University of Chicago, Illinois, U.S.A.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1883. ‡Clarke, W. P., J.P. 15 Hesketh-street, Southport.
1884. ‡Claxton, T. James. 461 St. Urbain-street, Montreal, Canada.
1889. §CLAYDEN, A. W., M.A., F.G.S. St. John's, Polsloe-road, Exeter.
1866. ‡Clayden, P. W. 13 Tavistock-square, London, W.C.
1890. *Clayton, William Wikely. Gipton Lodge, Leeds.
1850. ‡CLEGHORN, HUGH, M.D., F.L.S. Stravithie, St. Andrews, Scotland.
1859. ‡Cleghorn, John. Wick.
1875. ‡Clegram, T. W. B. Saul Lodge, near Stonehouse, Gloucestershire.
1861. §CLELAND, JOHN, M.D., D.Sc., F.R.S., Professor of Anatomy in the University of Glasgow. 2 The University, Glasgow.
1886. ‡Clifford, Arthur. Beechcroft, Edgbaston, Birmingham.
1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 3 Bardwell-road, Banbury-road, Oxford.
1893. ‡Clofford, William. 36 Mansfield-road, Nottingham.
Clonbrock, Lord Robert. Clonbrock, Galway.
1878. §Close, Rev. Maxwell H., F.G.S. 40 Lower Baggot-street, Dublin.
1873. ‡Clough, John. Bracken Bank, Keighley, Yorkshire.
1892. ‡Clouston, T. S., M.D. Tipperlinn House, Edinburgh.
1883. *CLOWES, FRANK, D.Sc., F.C.S., Professor of Chemistry in University College, Nottingham. 99 Waterloo-crescent, Nottingham.
1863. *Clutterbuck, Thomas. Warkworth, Acklington.
1881. *Clutton, William James. The Mount, York.
1885. ‡Clyne James. Rubislaw Den South, Aberdeen.
1868. ‡Coaks, J. B. Thorpe, Norwich.
1891. *Coates, Henry. Pitcullen House, Perth.
Cobb, Edward. Falkland House, St. Ann's, Lewes.
1884. §Cobb, John. Summerhill, Apperley Bridge, Leeds.
1895. *COBBOLD, FELIX T., M.A. The Lodge, Felixstowe, Suffolk.
1889. ‡Cochrane, Cecil A. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1889. ‡Cochrane, William. Oakfield House, Gosforth, Newcastle-upon-Tyne.
1892. ‡Cockburn, John. Glencorse House. Milton Bridge, Edinburgh.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G.S. Fairfield, Heaton, Bolton.
1881. *COFFIN, WALTER HARRIS, F.C.S. 94 Cornwall-gardens, South Kensington, London, S.W.
1865. ‡Coghill, H. Newcastle-under-Lyme.
1884. *Cohen, B. L., M.P. 30 Hyde Park-gardens, London, W.
1887. ‡Cohen, Julius B. Yorkshire College, Leeds.
1887. ‡Cohen, Sigismund. 111 Portland-street, Manchester.
1894. *Colby, Miss E. L. Carreg-wen, Aberystwith.
1895. *Colby, James George Ernest, M.A., F.R.C.S. Malton, Yorkshire.

Year of
Election.

1895. *Colby, William Henry. Carreg-wen, Aberystwith.
1853. ‡Colchester, William, F.G.S. Burwell, Cambridge.
1868. ‡*Colchester, W. P. Bassingbourn, Royston.*
1893. ‡Cole, Grenville A. J., F.G.S. Royal College of Science, Dublin.
1879. ‡Cole, Skelton. 387 Glossop-road, Sheffield.
1894. §§Colefax, H. Arthur, Ph.D., F.C.S. 14 Chester-terrace, Chester-square, London, S.W.
1893. ‡Coleman, J. B., F.C.S., A.R.C.S. University College, Nottingham.
1878. ‡Coles, John, Curator of the Map Collection R.G.S. 1 Savile-row, London, W.
1854. *Colfox, William, B.A. Westmead, Bridport, Dorsetshire.
1892. §Collet, Miss Clara E. 7 Coleridge-road, London, N.
1892. §Collie, Alexander. Harlaw House, Inverurie.
1887. ‡Collie, J. Norman, Ph.D., F.C.S. University College, Gower-street, London, W.C.
1887. ‡Collier, Thomas. Ashfield, Alderley Edge, Manchester.
1869. ‡Collier, W. F. Woodtown, Horrabridge, South Devon.
1893. §Collinge, Walter E. Mason College, Birmingham.
1854. ‡Collingwood, Cuthbert, M.A., M.B., F.L.S. 69 Great Russell-street, London, W.C.
1861. *Collingwood, J. Frederick, F.G.S. 96 Great Portland-street, London, W.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1876. ‡Collins, J. H., F.G.S. 60 Heber-road, Dulwich Rise, London, S.E.
1892. ‡Colman, H. G. Mason College, Birmingham.
1868. *Colman, J. J. Carrow House, Norwich; and 108 Cannon-street, London, E.C.
1882. ‡Colmer, Joseph G., C.M.G. Office of the High Commissioner for Canada, 9 Victoria-chambers, London, S.W.
1884. ‡Colomb, Sir J. C. R., F.R.G.S. Dromquinna, Kenmare, Kerry, Ireland; and Junior United Service Club, London, S.W.
1888. ‡Commans, R. D. Macaulay-buildings, Bath.
1884. ‡Common, A. A., LL.D., F.R.S., F.R.A.S. 63 Eaton-rise, Ealing, Middlesex, W.
1891. ‡Common, J. F. F. 21 Park-place, Cardiff.
1892. §Comyns, Frank, M.A., F.C.S. The Grammar School, Durham.
1884. ‡Conklin, Dr. William A. Central Park, New York, U.S.A.
1890. ‡Connon, J. W. Park-row, Leeds.
1871. *Connor, Charles C. Notting Hill House, Belfast.
1881. ‡Conroy, Sir John, Bart., M.A., F.R.S. Balliol College, Oxford.
1893. ‡Conway, Sir W. M., M.A., F.R.G.S. 21 Clanricarde-gardens, London, W.
1876. ‡Cook, James. 162 North-street, Glasgow.
1895. §Cooke, Miss Janette E. Holmwood Thorpe, Norwich.
1882. ‡Cooke, Major-General A. C., R.E., C.B., F.R.G.S. Palace-chambers, Ryder-street, London, S.W.
1876. *Cooke, Conrad W. 28 Victoria-street, London, S.W.
1881. ‡Cooke, F. Bishopshill, York.
1868. ‡Cooke, Rev. George H. Wanstead Vicarage, near Norwich.
1868. ‡Cooke, M. C., M.A. 2 Grosvenor-villas, Upper Holloway, London, N.
1884. ‡Cooke, R. P. Brockville, Ontario, Canada.
1878. ‡Cooke, Samuel, M.A., F.G.S. Poona, Bombay.
1881. ‡Cooke, Thomas. Bishopshill, York.
1883. ‡*Cooke-Taylor, R. Whateley. Frenchwood House, Preston.*
1883. ‡*Cooke-Taylor, Mrs. Frenchwood House, Preston.*
1865. ‡Cooksey, Joseph. West Bromwich, Birmingham.

Year of Election.

1888. ‡Cooley, George Parkin. Cavendish Hill, Sherwood, Nottingham.
1884. ‡Coon, John S. 604 Main-street, Cambridge Pt., Massachusetts, U.S.A.
1895. §Cooper, Charles Friend, M.I.E.E. 68 Victoria-street, Westminster, S.W.
1893. ‡Cooper, F. W. 14 Hamilton-road, Sherwood Rise, Nottingham.
1883. ‡Cooper, George B. 67 Great Russell-street, London, W.C.
1838. Cooper, James. 58 Pembridge-villas, Bayswater, London, W.
1868. ‡Cooper, W. J. New Maldon, Surrey.
1889. ‡Coote, Arthur. The Minories, Jesmond, Newcastle-upon-Tyne.
1884. ‡Cope, E. D. Philadelphia, U.S.A.
1878. ‡Cope, Rev. S. W. Bramley, Leeds.
1871. ‡Copeland, Ralph, Ph.D., F.R.A.S., Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh.
1885. ‡Copland, W., M.A. Tortorston, Peterhead, N.B.
1881. ‡Copperthwaite, H. Holgate Villa, Holgate-lane, York.
1842. Corbett, Edward. Grange-avenue, Levenshulme, Manchester.
1891. §Corbett, E. W. M. Y Fron, Pwllypant, Cardiff.
1887. *Corcoran, Bryan. 31 Mark-lane, London, E.C.
1894. §Corcoran, Miss Jessie R. The Chestnuts, Sutton, Surrey.
1881. §§Cordeaux, John. Great Cotes House, R.S.O., Lincoln.
1883. *Core, Professor Thomas H., M.A. Fallowfield, Manchester.
1870. *Corfield, W. H., M.A., M.D., F.C.S., F.G.S., Professor of Hygiene and Public Health in University College. 19 Savile-row, London, W.
1893. *Corner, Samuel, B.A., B.Sc. 95 Forest-road West, Nottingham.
1889. ‡Cornish, Vaughan. Ivy Cottage, Newcastle, Staffordshire.
1884. *Cornwallis, F. S. W. Linton Park, Maidstone.
1885. ‡Corry, John. Rosenheim, Parkhill-road, Croydon.
1888. ‡Corser, Rev. Richard K. 12 Beaufort-buildings East, Bath.
1891. ‡Cory, John, J.P. Vaindre Hall, near Cardiff.
1891. ‡Cory, Alderman Richard, J.P. Oscar House, Newport-road, Cardiff.
1883. ‡Costelloe, B. F. C., M.A., B.Sc. 33 Chancery-lane, London, W.C.
1891. *Cotsworth, Haldane Gwilt. G.W.R. Laboratory, Swindon, Wilts.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. King-street, Manchester.
1874. *Cotterill, J. H., M.A., F.R.S., Professor of Applied Mechanics. Royal Naval College, Greenwich, S.E.
1864. ‡Cotton, General Frederick C., R.E., C.S.I. 13 Longridge-road, Earl's Court-road, London, S.W.
1869. ‡Cotton, William. Pennsylvania, Exeter.
1879. ‡Cottrill, Gilbert I. Shepton Mallet, Somerset.
1876. ‡Couper, James. City Glass Works, Glasgow.
1876. ‡Couper, James, jun. City Glass Works, Glasgow.
1889. ‡Courtney, F. S. 77 Redcliffe-square, South Kensington, London, S.W.
1890. ‡Cousins, John James. Allerton Park, Chapel Allerton, Leeds.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
1872. *Cowan, Thomas William, F.L.S., F.G.S. 31 Belsize Park-gardens, London, N.W.
1886. ‡Cowen, Mrs. G. R. 9 The Ropewalk, Nottingham.
Cowie, The Very Rev. Benjamin Morgan, M.A., D.D., Dean of Exeter. The Deanery, Exeter.
1895. *Cowell, Philip H. Trinity College, Cambridge.

Year of Election.

1871. ‡Cowper, C. E. 6 Great George-street, Westminster, S.W.
1867. *Cox, Edward. Curdean, Meigle, N.B.
1867. *Cox, George Addison. Beechwood, Dundee.
1892. ‡Cox, Robert. 34 Drumsheugh-gardens, Edinburgh.
1882. ‡Cox, Thomas A., District Engineer of the S., P., and D. Railway. Lahore, Punjab. Care of Messrs. Grindlay & Co., Parliament-street, London, S.W.
1888. ‡Cox, Thomas W. B. The Chestnuts, Lansdowne, Bath.
1867. ‡Cox, William. Foggley, Lochee, by Dundee.
1883. §Crabtree, William, M.Inst.C.E. 126 Manchester-road, Southport.
1890. ‡Cradock, George. Wakefield.
1892. *Craig, George A. 66 Edge-lane, Liverpool.
1884. §§Craigie, Major P. G., F.S.S. 6 Lyndhurst-road, Hampstead, London, N.W.
1876. ‡Cramb, John. Larch Villa, Helensburgh, N.B.
1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
1884. ‡Crathern, James. Sherbrooke-street, Montreal, Canada.
1887. §§Craven, John. Smedley Lodge, Cheetham, Manchester.
1887. *Craven, Thomas, J.P. Woodheyes Park, Ashton-upon-Mersey, Cheshire.
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Slateford, Edinburgh.
1871. *Crawford and Balcarres, The Right Hon. the Earl of, K.T., LL.D., F.R.S., F.R.A.S. Dun Echt, Aberdeen.
1846. *Crawshaw, The Right Hon. Lord. Whatton, Loughborough, Leicestershire.
1890. §Crawshaw, Charles B. Rufford Lodge, Dewsbury.
1883. *Crawshaw, Edward, F.R.G.S. 25 Tollington-park, London, N.
1870. *Crawshay, Mrs. Robert. Cathedine, Bwlch, Breconshire.
1885. §Creak, Captain E. W., R.N., F.R.S. 36 Kidbrooke Park-road, Blackheath, London, S.E.
1879. ‡Creswick, Nathaniel. Chantry Grange, near Sheffield.
1876. *Crewdson, Rev. George. St. Mary's Vicarage, Windermere.
1887. *Crewdson, Theodore. Norcliffe Hall, Handforth, Manchester.
1880. *Crisp, Frank, B.A., LL.B., F.L.S., F.G.S. 5 Lansdowne-road, Notting Hill, London, W.
1890. *Croft, W. B., M.A. Winchester College, Hampshire.
1878. ‡Croke, John O'Byrne, M.A. University College, Stephen's Green, Dublin.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1885. ‡Crombie, Charles W. 41 Carden-place, Aberdeen.
1885. ‡Crombie, John, jun. Daveston, Aberdeen.
1885. ‡Crombie, J. W., M.A., M.P. Balgownie Lodge, Aberdeen.
1885. ‡Crombie, Theodore. 18 Albyn-place, Aberdeen.
1887. ‡Crompton, A. 1 St. James's-square, Manchester.
1886. ‡*Crompton, Dickinson W. 40 Harborne-road, Edgbaston, Birmingham.*
1887. §Crook, Henry T. 9 Albert-square, Manchester.
1865. §Crookes, William, F.R.S., F.C.S. 7 Kensington Park-gardens, London, W.
1879. ‡Crookes, Mrs. 7 Kensington Park-gardens, London, W.
1870. ‡Crosfield, C. J. Gledhill, Sefton Park, Liverpool.
1894. *Crosfield, Miss Margaret C. Undercroft, Reigate.
1870. *Crosfield, William, M.P. Annesley, Aigburth, Liverpool.
1890. ‡Cross, E. Richard, LL.B. Harwood House, New Parks-crescent, Scarborough.
1887. §Cross, John. Beaucliffe, Alderley Edge, Cheshire.

Year of Election.

1861. ‡Cross, Rev. John Edward, M.A., F.G.S. Halecote, Grange-over-Sands.
1886. ‡*Crosskey, Cecil. 117 Gough-road, Birmingham.*
1853. ‡Crosskill, William. Beverley, Yorkshire.
1870. *Crossley, Edward, F.R.A.S. Bemerside, Halifax.
1871. ‡*Crossley, Herbert. Ferney Green, Bowness, Ambleside.*
1887. *Crossley, William J. Glenfield, Bowdon, Cheshire.
1894. *Crosweller, William Thomas, F.Z.S., F.I.Inst. Kent Lodge, Sidcup, Kent.
1894. §Crow, C. F. Home Lea, Woodstock-road, Oxford.
1883. ‡Crowder, Robert. Stanwix, Carlisle.
1882. §Crowley, Frederick. Ashdell, Alton, Hampshire.
1890. *Crowley, Ralph Henry. Bramley Oaks, Croydon.
1883. ‡*Crowther, Elon. Cambridge-road, Huddersfield.*
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-upon-Tyne.
1885. ‡Cruickshank, Alexander, LL.D. 20 Rose-street, Aberdeen.
1888. ‡Crummack, William J. London and Brazilian Bank, Rio de Janeiro, Brazil.
1873. ‡Crust, Walter. Hall-street, Spalding.
1883. *Cryer, Major J. H. The Grove, Manchester-road, Southport.
Culley, Robert. Bank of Ireland, Dublin.
1883. *Culverwell, Edward P. 40 Trinity College, Dublin.
1878. ‡Culverwell, Joseph Pope. St. Lawrence Lodge, Sutton, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1874. ‡Cumming, Professor. 33 Wellington-place, Belfast.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1882. *CUNNINGHAM, Lieut.-Colonel ALLAN, R.E., A.I.C.E. 20 Essex-villas, Kensington, London, W.
1887. ‡Cunningham, David, M.Inst.C.E., F.R.S.E., F.S.S. Harbour-chambers, Dundee.
1877. *CUNNINGHAM, D. J., M.D., D.C.L., F.R.S., F.R.S.E., Professor of Anatomy in Trinity College, Dublin.
1891. ‡Cunningham, J. H. 4 Magdala-crescent, Edinburgh.
1852. ‡Cunningham, John. Macedon, near Belfast.
1892. ‡Cunningham, Very Rev. John. St. Bernard's College, Edinburgh.
1885. ‡CUNNINGHAM, J. T., B.A. Biological Laboratory, Plymouth.
1869. ‡CUNNINGHAM, ROBERT O., M.D., F.L.S., F.G.S., Professor of Natural History in Queen's College, Belfast.
1883. *CUNNINGHAM, Rev. WILLIAM, D.D., D.Sc. Trinity College, Cambridge.
1892. ‡*Cunningham, William. 14 Inverleith-gardens, Edinburgh.*
1850. ‡Cunningham, Rev. William Bruce. Prestonpans, Scotland.
1892. §Cunningham-Craig, E. H. Clare College, Cambridge.
1885. ‡*Curphey, William S. 15 Bute-mansions, Hill Head, Cardiff.*
1892. *Currie, James, jun. Larkfield, Golden Acre, Edinburgh.
1884. ‡Currier, John McNab. Newport, Vermont, U.S.A.
1878. ‡Curtis, William. Caramore, Sutton, Co. Dublin.
1884. ‡Cushing, Frank Hamilton. Washington, U.S.A.
1883. ‡Cushing, Mrs. M. Croydon, Surrey.
1881. §Cushing, Thomas, F.R.A.S. India Store Depôt, Belvedere-road, Lambeth, London, S.W.

1889. ‡Dagger, John H., F.I.C., F.C.S. Endon, Staffordshire.
1854. ‡Daglish, Robert, M.Inst.C.E. Orrell Cottage, near Wigan.

Year of Election.

1883. ‡Dähne, F. W., Consul of the German Empire. 18 Somerset-place, Swansea.

1889. *Dale, Miss Elizabeth. Westbourne, Buxton, Derbyshire.

1887. ‡*Dale, Henry F., F.R.M.S., F.Z.S. Royal London Yacht Club, 2 Savile-row, London, W.*

1863. ‡Dale, J. B. South Shields.

1867. ‡Dalgleish, W. Dundee.

1894.§§Dalgleish, W. Scott, M.A., LL.D. 25 Mayfield-terrace, Edinburgh.

1870. ‡Dallinger, Rev. W. H., LL.D., F.R.S., F.L.S. Ingleside, Newstead-road, Lee, London, S.E.

Dalton, Edward, LL.D. Dunkirk House, Nailsworth.

1862. ‡Danby, T. W., M.A., F.G.S. The Crouch, Seaford, Sussex.

1876. ‡Dansken, John. 4 Eldon-terrace, Partickhill, Glasgow.

1849. *Danson, Joseph, F.C.S. Montreal, Canada.

1894.§§Darbishire, B. V., M.A., F.R.G.S. 1 Savile-row, London, W.

1861. *Darbishire, Robert Dukinfield, B.A., F.G.S. 26 George-street, Manchester.

1876. ‡*Darling, G. Erskine. 247 West George-street, Glasgow.*

1882. ‡Darwin, Francis, M.A., M.B., F.R.S., F.L.S. Wychfield, Huntingdon-road, Cambridge.

1881. *Darwin, George Howard, M.A., LL.D., F.R.S., F.R.A.S., Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.

1878. *Darwin, Horace. The Orchard, Huntingdon-road, Cambridge.

1894. §Darwin, Major Leonard, Sec. R.G.S. 18 Wetherby-place, South Kensington, London, S.W.

1882. ‡Darwin, W. E., B.A., F.G.S. Bassett, Southampton.

1888. ‡Daubeny, William M. 1 Cavendish-crescent, Bath.

1872. ‡Davenport, John T. 64 Marine-parade, Brighton.

1880. *Davey, Henry, M.Inst.C.E., F.G.S. 3 Prince's-street, Westminster, S.W.

1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, London, E.C.

1870. ‡Davidson, Alexander, M.D. 2 Gambier-terrace, Liverpool.

1885. ‡Davidson, Charles B. Roundhay, Fonthill-road, Aberdeen.

1891. ‡Davies, Andrew, M.D. Cefn Parc, Newport, Monmouthshire.

1890. ‡*Davies, Arthur. East Brow Cottage, near Whitby.*

1875. ‡Davies, David. 2 Queen's-square, Bristol.

1887. §Davies, David. 55 Berkley-street, Liverpool.

1870. ‡Davies, Edward, F.C.S. Royal Institution, Liverpool.

1887. *Davies, H. Rees. Treborth, Bangor, North Wales.

1893. *Davies, Rev. T. Witton, B.A. Midland Baptist College, Nottingham.

1842. *Davies-Colley, Dr. Thomas. Newton, near Chester.*

1887. ‡Davies-Colley, T. C. Hopedene, Kersal, Manchester.

1873. *Davis, Alfred. 13 St. Ermin's-mansions, London, S.W.

1870. *Davis, A. S. St. George's School, Roundhay, near Leeds.

1864. ‡Davis, Charles E., F.S.A. 55 Pulteney-street, Bath.

1842. Davis, Rev. David, B.A. Almswood, Evesham.

1882. ‡Davis, Henry C. Berry Pomeroy, Springfield-road, Brighton.

1883. ‡Davis, Robert Frederick, M.A. Earlsfield, Wandsworth Common, London, S.W.

1885. *Davis, Rudolf. Almswood, Evesham.

1891. ‡Davis, W. 48 Richmond-road, Cardiff.

1886. ‡Davis, W. H. Hazeldean, Pershore-road, Birmingham.

1886. ‡Davison, Charles, M.A. 373 Gillott-road, Birmingham.

Year of Election.

1864. *Davison, Richard. Beverley-road, Great Driffield, Yorkshire.
1857. ‡DAVY, EDMUND W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1869. ‡Daw, John. Mount Radford, Exeter.
1869. ‡Daw, R. R. M. Bedford-circus, Exeter.
1860. *Dawes, John T., F.G.S. Cefn Mawr Hall, Mold, North Wales.
1864. ‡DAWKINS, W. BOYD, M.A., F.R.S., F.S.A., F.G.S., Professor of Geology and Palæontology in the Victoria University, Owens College, Manchester. Woodhurst, Fallowfield, Manchester.
1886. ‡Dawson, Bernard. The Laurels, Malvern Link.
1891. ‡Dawson, Edward. 2 Windsor-place, Cardiff.
1885. *Dawson, Lieut.-Colonel H. P., R.A. East Holt, Alverstoke, Gosport.
1884. ‡Dawson, Samuel. 258 University-street, Montreal, Canada.
1855. §DAWSON, Sir WILLIAM, C.M.G., M.A., LL.D., F.R.S., F.G.S. 293 University-street, Montreal, Canada.
1859. *Dawson, Captain William G. The Links, Plumstead Common, Kent.
1892. ‡Day, J. C., F.C.S. 36 Hillside-crescent, Edinburgh.
1870. *DEACON, G. F., M.Inst.C.E. 19 Warwick-square, London, S.W.
1861. ‡Deacon, Henry. Appleton House, near Warrington.
1887. ‡Deakin, H. T. Egremont House, Belmont, near Bolton.
1861. ‡Dean, Henry. Colne, Lancashire.
1884. *Debenham, Frank, F.S.S. 1 Fitzjohn's-avenue, London, N.W.
1866. ‡DEBUS, HEINRICH, Ph.D., F.R.S., F.C.S. 1 Obere Sophienstrasse, Cassel, Hessen.
1884. ‡Deck, Arthur, F.C.S. 9 King's-parade, Cambridge.
1893. §Deeley, R. M. 10 Charnwood-street, Derby.
1878. ‡Delany, Rev. William. St. Stanislaus College, Tullamore.
1879. ‡*De la Sala, Colonel. Sevilla House, Navarino-road, London, N.E.*
1884. *De Laune, C. De L. F. Sharsted Court, Sittingbourne.
1889. ‡Dendy, Frederick Walter. 3 Mardale-parade, Gateshead.
1873. ‡Denham, Thomas, J.P. Huddersfield.
1884. ‡*Denman, Thomas W. Lamb's-buildings, Temple, London, E.C.*
1889. §DENNY, ALFRED, F.L.S., Professor of Biology in the Firth College, Sheffield.
Dent, William Yerbury. Royal Arsenal, Woolwich.
1874. §DE RANCE, CHARLES E., F.G.S. 55 Stoke-road, Shelton, Stoke-upon-Trent.
1874. *Derham, Walter, M.A., LL.M., F.G.S. 63 Queensborough-terrace, London, W.
1878. ‡De Rinzy, James Harward. Khelat Survey, Sukkur, India.
1868. ‡Dessé, Etheldred, M.B., F.R.C.S. 43 Kensington Gardens-square, Bayswater, London, W.
1894. *Deverell, F. H. 13 Lawn-terrace, Blackheath, London, S.E.
1868. ‡DEWAR, JAMES, M.A., LL.D., F.R.S., F.R.S.E., F.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. 1 Scroope-terrace, Cambridge.
1881. ‡Dewar, Mrs. 1 Scroope-terrace, Cambridge.
1883. ‡Dewar, James, M.D., F.R.C.S.E. Drylaw House, Davidson's Mains, Midlothian, N.B.
1884. *Dewar, William, M.A. Rugby School, Rugby.
1872. ‡Dewick, Rev. E. S., M.A., F.G.S. 26 Oxford-square, London, W.
1887. ‡DE WINTON, Colonel Sir F., G.C.M.G., C.B., D.C.L., LL.D., F.R.G.S. United Service Club, Pall Mall, London, S.W.

Year of Election.

1884. ‡De Wolf, O. C., M.D. Chicago, U.S.A.
1873. *Dew-Smith, A. G., M.A. Trinity College, Cambridge.
1889. ‡Dickinson, A. H. The Wood, Maybury, Surrey.
1863. ‡Dickinson, G. T. Lily-avenue, Jesmond, Newcastle-upon-Tyne.
1887. ‡Dickinson, Joseph, F.G.S. South Bank, Pendleton.
1884. ‡Dickson, Charles R., M.D. Wolfe Island, Ontario, Canada.
1881. ‡Dickson, Edmund. West Cliff-road, Birkdale, Southport.
1887. §Dickson, H. N. 125 Woodstock-road, Oxford.
1885. ‡Dickson, Patrick. Laurencekirk, Aberdeen.
1883. ‡Dickson, T. A. West Cliff, Preston.
1862. *Dilke, The Right Hon. Sir Charles Wentworth, Bart., M.P., F.R.G.S. 76 Sloane-street, London, S.W.
1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.
1869. ‡Dingle, Edward. 19 King-street, Tavistock.
1876. ‡*Ditchfield, Arthur. 12 Taviton-street, Gordon-square, London, W.C.*
1884. ‡Dix, John William H. Bristol.
1874. *Dixon, A. E., M.D., Professor of Chemistry in Queen's College, Cork. Mentone Villa, Sunday's Well, Cork.
1883. ‡Dixon, Miss E. 2 Cliff-terrace, Kendal.
1888. §Dixon, Edward T. Messrs. Lloyds, Barnetts, & Bosanquets' Bank, 54 St. James's-street, London, S.W.
1886. ‡Dixon, George. 42 Augustus-road, Edgbaston, Birmingham.
1879. *Dixon, Harold B., M.A., F.R.S., F.C.S., Professor of Chemistry in the Owens College, Manchester. Birch Hall, Rusholme, Manchester.
1885. ‡Dixon, John Henry. Inveran, Poolewe, Ross-shire, N.B.
1887. ‡Dixon, Thomas. Buttershaw, near Bradford, Yorkshire.
1885. ‡Doak, Rev. A. 15 Queen's-road, Aberdeen.
1890. ‡Dobbie, James J., D.Sc. University College, Bangor, North Wales.
1885. §Dobbin, Leonard. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. 34 Westbourne-park, London, W.
1892. ‡Dobie, W. Fraser. 47 Grange-road, Edinburgh.
1891. ‡Dobson, G. Alkali and Ammonia Works, Cardiff.
1878. *Dobson, G. E., M.A., M.B., F.R.S., F.L.S. Adrigole, Spring Grove, Isleworth.
1893. §§Dobson, W. E., J.P. Lenton-road, The Park, Nottingham.
1864. *Dobson, William. Oakwood, Bathwick Hill, Bath.
1894. §§Dockar-Drysdale, Mrs. 39 Belsize-park, London, N.W.
1875. *Docwra, George, jun. 108 London-road, Gloucester.
1870. *Dodd, John. Nunthorpe-avenue, York.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1889. ‡Dodson, George, B.A. Downing College, Cambridge.
1893. ‡Donald, Charles W. Kinsgarth, Braid-road, Edinburgh.
1885. ‡Donaldson, James, M.A., LL.D., F.R.S.E., Senior Principal of the University of St. Andrews, N.B.
1882. ‡Donaldson, John. Tower House, Chiswick, Middlesex.
1869. ‡Donisthorpe, G. T. St. David's Hill, Exeter.
1877. *Donkin, Bryan, M.Inst.C.E. The Mount, Wray Park, Reigate.
1889. ‡Donkin, R. S., M.P. Campville, North Shields.
1861. ‡Donnelly, Major-General Sir J. F. D., R.E., K.C.B. South Kensington Museum, London, S.W.
1887. ‡Dorning, Elias, M.Inst.C.E., F.G.S. 41 John Dalton-street, Manchester.
1881. ‡Dorrington, John Edward. Lypiatt Park, Stroud.
1867. ‡Dougall, Andrew Maitland, R.N. Scotscraig, Tayport, Fifeshire.

Year of
Election.

1863. *Doughty, Charles Montagu. Henwick, Newbury.
1876. **Douglas, Rev. G. C. M., D.D. 18 Royal-crescent West, Glasgow.*
1877. *Douglass, Sir James N., F.R.S., M.Inst.C.E. Stella House, Dulwich, London, S.E.
1884. ‡Douglass, William Alexander. Freehold Loan and Savings Company, Church-street, Toronto, Canada.
1890. ‡Dovaston, John. West Felton, Oswestry.
1883. ‡Dove, Arthur. Crown Cottage, York.
1884. ‡Dove, Miss Frances. St. Leonard's, St. Andrews, N.B.
1884. ‡Dowe, John Melnotte. 69 Seventh-avenue, New York, U.S.A.
1876. ‡Dowie, Mrs. Muir. Golland, by Kinross, N.B.
1894.§§Dowie, Robert Chambers. 13 Carter-street, Higher Broughton, Manchester.
1884. *Dowling, D. J. Bromley, Kent.
1857. ‡Downing, S., LL.D. 4 The Hill, Monkstown, Co. Dublin.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, Joseph Emerson, M.Inst.C.E. 3 Great Queen-street, London, S.W.
1887. ‡Doxey, R. A. Slade House, Levenshulme, Manchester.
1894. §Doyne, R. W., F.R.C.S. 28 Beaumont-street, Oxford.
1883. ‡Draper, William. De Grey House, St. Leonard's, York.
1892. *Dreghorn, David, J.P. Greenwood, Pollokshields, Glasgow.
1868. ‡Dresser, Henry E., F.Z.S. 110 Cannon-street, London, E.C.
1890. ‡Drew, John. 12 Harringay-park, Crouch End, Middlesex, N.
1892. ‡Dreyer, John L. E., M.A., Ph.D., F.R.A.S. The Observatory, Armagh.
1887. ‡Dreyfus, Dr. Daisy Mount, Victoria Park, Manchester.
1893. §Druce, G. Claridge, M.A., F.L.S. 118 High-street, Oxford.
1889. ‡Drummond, Dr. 6 Saville-place, Newcastle-upon-Tyne.
1892. ‡Du Bois, Dr. H. Mittelstrasse, 39, Berlin.
1889. ‡Du Chaillu, Paul B. Care of John Murray, Esq., 50a Albemarle-street, London, W.
1856. *Ducie, The Right. Hon. Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, London, W.; and Tortworth Court, Wotton-under-Edge.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. Christchurch Vicarage, Chester.
1895. *Duddell, William. Kensington Infirmary, Marloes-road, London, W.
1867. *Duff, The Right Hon. Sir Mountstuart Elphinstone Grant-, G.C.S.I., F.R.S., F.R.G.S. York House, Twickenham.
1852. ‡Dufferin and Ava, The Most Hon. the Marquis of, K.P., G.C.B., G.C.M.G., G.C.S.I., D.C.L., LL.D., F.R.S., F.R.G.S. Clandeboye, near Belfast, Ireland.
1877. ‡Duffey, George F., M.D. 30 Fitzwilliam-place, Dublin.
1875. ‡Duffin, W. E. L'Estrange. Waterford.
1890. ‡Dufton, S. F. Trinity College, Cambridge.
1884. ‡Dugdale, James H. 9 Hyde Park-gardens, London, W.
1883. §Duke, Frederic. Conservative Club, Hastings.
1892. ‡Dulier, Colonel E., C.B. 27 Sloane-gardens, London, S.W.
1866. *Duncan, James. 9 Mincing-lane, London, E.C.
1891. *Duncan, John, J.P. 'South Wales Daily News' Office, Cardiff.
1880. ‡Duncan, William S. 143 Queen's-road, Bayswater, London, W.
1881. ‡Duncombe, The Hon. Cecil, F.G.S. Nawton Grange, York.
1893. *Dunell, George Robert. 9 Grove Park-terrace, Chiswick, London, W.
1892. ‡Dunham, Miss Helen Bliss. Messrs. Morton, Rose, & Co., Bartholomew House, London, E.C.
1881. ‡Dunhill, Charles H. Gray's-court, York.
1865. ‡Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.

Year of Election.

1882. ‡Dunn, J. T., M.Sc., F.C.S. High School for Boys, Gateshead-on-Tyne.
1883. ‡Dunn, Mrs. Denton Grange, Gateshead-on-Tyne.
1876. ‡Dunnachie, James. 2 West Regent-street, Glasgow.
1878. ‡Dunne, D. B., M.A., Ph.D., Professor of Logic in the Catholic University of Ireland. 4 Clanwilliam-place, Dublin.
1884. §§Dunnington, F. P. University Station, Charlottesville, Virginia, U.S.A.
1859. ‡Duns, Rev. John, D.D., F.R.S.E. New College, Edinburgh.
1893. *Dunstan, M. J. R. 9 Hamilton-drive, Nottingham.
1885. *Dunstan, Wyndham R., M.A., F.R.S., Sec.C.S., Lecturer on Chemistry at St. Thomas's Hospital and Professor of Chemistry to the Pharmaceutical Society of Great Britain. 17 Bloomsbury-square, London, W.C.
1869. ‡D'Urban, W. S. M., F.L.S. Moorlands, Exmouth, Devon.
1895. *Dwerryhouse, Arthur R. 8 Livingston-avenue, Sefton Park, Liverpool.
1887. ‡Dyason, John Sanford, F.R.G.S. Boscobel-gardens, N.W.
1884. ‡Dyck, Professor Walter. The University, Munich.
1885. *Dyer, Henry, M.A., D.Sc. 8 Highburgh-terrace, Dowanhill, Glasgow.
1869. *Dymond, Edward E. Oaklands, Aspley Guise, Bletchley.
1895. §Dymond, Thomas S., F.C.S. County Technical Laboratory, Chelmsford.

1868. ‡Eade, Sir Peter, M.D. Upper St. Giles's-street, Norwich.
1895. §Earle, Hardman H. 29 Queen Anne's-gate, Westminster, S.W.
1877. ‡Earle, Ven. Archdeacon, M.A. West Alvington, Devon.
1888. ‡Earson, H. W. P. 11 Alexandra-road, Clifton, Bristol.
1874. ‡Eason, Charles. 30 Kenilworth-square, Rathgar, Dublin.
1871. *Easton, Edward, M.Inst.C.E., F.G.S. 16 Great College-street, Westminster, S.W.
1863. ‡Easton, James. Nest House, near Gateshead, Durham.
1876. ‡Easton, John. Durie House, Abercromby-street, Helensburgh, N.B.
1883. ‡Eastwood, Miss. Littleover Grange, Derby.
1893. §Ebbs, Alfred B. Northumberland-alley, Fenchurch-street, London, E.C.
1887. *Eccles, Mrs. S. White Coppice, Chorley, Lancashire.
1884. ‡Eckersley, W. T. Standish Hall, Wigan, Lancashire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
1870. *Eddison, John Edwin, M.D., M.R.C.S. 6 Park-square, Leeds.
*Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.
1887. ‡Ede, Francis J., F.G.S. Silchar, Cachar, India.
Eden, Thomas. Talbot-road, Oxton.
1884. *Edgell, Rev. R. Arnold, M.A., F.C.S. The College House, Leamington.
1887. §Edgeworth, F. Y., M.A., D.C.L., F.S.S., Professor of Political Economy in the University of Oxford. All Souls College, Oxford.
1870. *Edmonds, F. B. 6 Furnival's Inn, London, E.C.
1883. ‡Edmonds, William. Wiscombe Park, Honiton, Devon.
1888. *Edmunds, Henry. Antron, 71 Upper Tulse-hill, London, S.W.
1884. *Edmunds, James, M.D. 29 Dover-street, Piccadilly, London, W.
1883. ‡Edmunds, Lewis, D.Sc., LL.B., F.G.S. 1 Garden-court, Temple, London, E.C.
1867. *Edward, Allan. Farington Hall, Dundee.
1855. *Edwards, Professor J. Baker, Ph.D., D.C.L. Montreal, Canada.

Year of Election.

1884. ‡Edwards, W. F. Niles, Michigan, U.S.A.
1887. *Egerton of Tatton, The Right Hon. Lord. Tatton Park, Knutsford.
1876. ‡Elder, Mrs. 6 Claremont-terrace, Glasgow.
1890. §Elford, Percy. St. John's College, Oxford.
1885. *Elgar, Francis, LL.D., M.Inst.C.E., F.R.S.E. 113 Cannon-street, London, E.C.
1868. ‡Elger, Thomas Gwyn Empy, F.R.A.S. Manor Cottage, Kempston, Bedford.
1885. ‡Ellingham, Frank. Thorpe St. Andrew, Norwich.
1883. ‡Ellington, Edward Bayzand, M.Inst.C.E. Palace-chambers, Bridge-street, Westminster, S.W.
1891. ‡Elliott, A. C., D.Sc., Professor of Engineering in University College, Cardiff. 2 Plasturton-avenue, Cardiff.
1864. ‡Elliott, E. B. Washington, U.S.A.
1883. *ELLIOTT, EDWIN BAILEY, M.A., F.R.S., F.R.A.S., Waynflete Professor of Pure Mathematics in the University of Oxford. 4 Bardwell-road, Oxford.
Elliott, John Fogg. Elvet Hill, Durham.
1879. ‡Elliott, Joseph W. Post Office, Bury, Lancashire.
1886. ‡Elliott, Thomas Henry, F.S.S. Board of Agriculture, 4 Whitehall-place, London, S.W.
1877. ‡Ellis, Arthur Devonshire. Thurnscoe Hall, Rotherham, Yorkshire.
1875. *Ellis, H. D. 6 Westbourne-terrace, Hyde Park, London, W.
1883. ‡*Ellis John. 17 Church-street, Southport.*
1880. *ELLIS, JOHN HENRY. Woodland House, Plymouth.
1891. §Ellis, Miss M. A. 2 Southwick-place, London, W.
1884. ‡Ellis, W. Hodgson. Toronto, Canada.
1869. ‡ELLIS, WILLIAM HORTON. Hartwell House, Exeter.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1887. ‡Elmy, Ben. Congleton, Cheshire.
1862. ‡Elphinstone, Sir H. W., Bart., M.A., F.L.S. 2 Stone-buildings, Lincoln's Inn, London, W.C.
1883. ‡Elwes, Captain George Robert. Bossington, Bournemouth.
1887. §ELWORTHY, FREDERICK T. Foxdown, Wellington, Somerset.
1870. *ELY, The Right Rev. Lord ALWYNE COMPTON, D.D., Lord Bishop of. The Palace, Ely, Cambridgeshire.
1863. ‡Embleton, Dennis, M.D. 19 Claremont-place, Newcastle-upon-Tyne.
1891. ‡Emerton, Wolseley. Banwell Castle, Somerset.
1891. ‡Emerton, Mrs. Wolseley. Banwell Castle, Somerset.
1884. ‡Emery, Albert H. Stamford, Connecticut, U.S.A.
1863. ‡Emery, The Ven. Archdeacon, B.D. Ely, Cambridgeshire.
1858. ‡Empson, Christopher. Bramhope Hall, Leeds.
1890. ‡Emsley, Alderman W. Richmond House, Richmond-road, Headingley, Leeds.
1894. §§Emtage, W. T. A. University College, Nottingham.
1866. ‡Enfield, Richard. Low Pavement, Nottingham.
1884. ‡England, Luther M. Knowlton, Quebec, Canada.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
1869. ‡*English, J. T. Wayfield House, Stratford-on-Avon.*
1883. ‡Entwistle, James P. Beachfield, 2 Westclyffe-road, Southport.
1869. *Enys, John Davis. Enys, Penryn, Cornwall.
1844. ‡ERICHSEN, Sir JOHN ERIC, Bart., LL.D., F.R.S., F.R.C.S., President of, and Emeritus Professor of Surgery in, University College, London. 6 Cavendish-place, London, W.
1894. §Erskine-Murray, James R. 40 Montgomerie-drive, Glasgow.
1864. *Eskrigge, R. A., F.G.S. 18 Hackins-hey, Liverpool.

Year of Election.

1862. *Esson, William, M.A., F.R.S., F.C.S., F.R.A.S. Merton College, and 13 Bradmore-road, Oxford.
1878. ‡Estcourt, Charles, F.C.S. 8 St. James's-square, John Dalton-street, Manchester.
1887. *Estcourt, Charles. Vyrniew House, Talbot-road, Old Trafford, Manchester.
1887. *Estcourt, P. A., F.C.S., F.I.C. 20 Albert-square, Manchester.
1869. ‡Etheridge, Robert, F.R.S., F.R.S.E., F.G.S. 14 Carlyle-square, London, S.W.
1888. ‡Etheridge, Mrs. 14 Carlyle-square, London, S.W.
1883. §Eunson, Henry J., F.G.S., Assoc.M.Inst.C.E. Vizianagram, Madras.
1891. ‡Evan-Thomas, C., J.P. The Gnoll, Neath, Glamorganshire.
1881. ‡Evans, Alfred, M.A., M.B. Pontypridd.
1889. *Evans, A. H. Care of R. H. Porter, 18 Prince's-street, W.
1887. *Evans, Mrs. Alfred W. A. Spring Villa, New Mills, near Stockport, Derbyshire.
1870. *Evans, Arthur John, F.S.A. 33 Holywell, Oxford.
1865. *Evans, Rev. Charles, M.A. 41 Lancaster-gate, London, W.
1891. ‡Evans, Franklen. Llwynarthen, Castleton, Cardiff.
1889. ‡Evans, Henry Jones. Greenhill, Whitchurch, Cardiff.
1884. ‡Evans, Horace L. 6 Albert-buildings, Weston-super-Mare.
1883. *Evans, James C. Morannedd, Eastbourne-road West, Birkdale Park, Southport.
1883. *Evans, Mrs. James C. Morannedd, Eastbourne-road West, Birkdale Park, Southport.
1861. *Evans, Sir John, K.C.B., D.C.L., LL.D., D.Sc., Treas.R.S., F.S.A., F.L.S., F.G.S. Nash Mills, Hemel Hempstead.
1881. ‡Evans, Lewis. Llanfyrnach R.S.O., Pembrokeshire.
1885. **Evans, Percy Bagnall. The Spring, Kenilworth.*
1875. ‡Evans, Sparke. 3 Apsley-road, Clifton, Bristol.
1865. *Evans, William. The Spring, Kenilworth.
1891. ‡Evans, William Llewellin. Guildhall-chambers, Cardiff.
1886. ‡Eve, A. S. Marlborough College, Wilts.
1871. ‡Eve, H. Weston, M.A. University College, London, W.C.
1868. *Everett, J. D., M.A., D.C.L., F.R.S., F.R.S.E., Professor of Natural Philosophy in Queen's College, Belfast. Derryvolgie, Belfast.
1895. §Everett, W. H., B.A. Belfast.
1863. *Everitt, George Allen, F.R.G.S. Knowle Hall, Warwickshire.
1886. ‡Everitt, William E. Finstall Park, Bromsgrove.
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡Ewart, J. Cossar, M.D., F.R.S., Professor of Natural History in the University of Edinburgh.
1874. ‡Ewart, Sir W. Quartus, Bart. Glenmachan, Belfast.
1876. *Ewing, James Alfred, M.A., B.Sc., F.R.S., F.R.S.E., M.Inst. C.E., Professor of Mechanism and Applied Mathematics in the University of Cambridge.
1883. ‡Ewing, James L. 52 North Bridge, Edinburgh.
1871. *Exley, John T., M.A. 1 Cotham-road, Bristol.
1884. *Eyerman, John, F.Z.S. Oakhurst, Easton, Pennsylvania, U.S.A.
1882. ‡Eyre, G. E. Briscoe. Warrens, near Lyndhurst, Hants.
Eyton, Charles. Hendred House, Abingdon.

1890. ‡Faber, Edmund Beckett. Straylea, Harrogate.
1865. *Fairley, Thomas, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1886. ‡Fairley, William. Beau Desert, Rugeley, Staffordshire.

Year of Election.

1864. ‡*Falkner, F. H. Lyncombe, Bath.*
1883. ‡Fallon, Rev. W. S 9 St. James's-square, Cheltenham.
1877. §FARADAY, F. J., F.L.S., F.S.S. College-chambers, 17 Brazenose-street, Manchester.
1891. ‡Fards, G. Penarth.
1892. *Farmer, J. Bretland, M.A., F.L.S. Royal College of Science, London, S.W.
1886. ‡Farncombe, Joseph, J.P. Lewes.
1879. *Farnworth, Ernest. Rosslyn, Goldthorn Hill, Wolverhampton.
1883. ‡Farnworth, Walter. 86 Preston New-road, Blackburn.
1883. ‡Farnworth, William. 86 Preston New-road, Blackburn.
1885. ‡Farquhar, Admiral. Carlogie, Aberdeen.
1886. ‡Farquharson, Colonel J., R.E. Ordnance Survey Office, Southampton.
1859. ‡Farquharson, Robert F. O. Haughton, Aberdeen.
1885. ‡Farquharson, Mrs. R. F. O. Haughton, Aberdeen.
1866. *FARRAR, The Very Rev. FREDERIC WILLIAM, D.D., F.R.S. The Deanery, Canterbury.
1883. ‡Farrell, John Arthur. Moynalty, Kells, North Ireland.
1857. ‡Farrelly, Rev. Thomas. Royal College, Maynooth.
1869. *Faulding, Joseph. Boxley House, Tenterden, Kent.
1883. ‡Faulding, Mrs. Boxley House, Tenterden, Kent.
1887. §Faulkner, John. 13 Great Ducie-street, Strangeways, Manchester.
1890. *Fawcett, F. B. University College, Bristol.
1886. §Felkin, Robert W., M.D., F.R.G.S. 8 Alva-street, Edinburgh.
Fell, John B. Spark's Bridge, Ulverstone, Lancashire.
1864. *FELLOWS, FRANK P., K.S.J.J., F.S.A., F.S.S. 8 The Green, Hampstead, London, N.W.
1852. ‡Fenton, S. Greame. Keswick, near Belfast.
1883. ‡Fenwick, E. H. 29 Harley-street, London, W.
1890. ‡Fenwick, T. Chapel Allerton, Leeds.
1876. ‡Ferguson, Alexander A. 11 Grosvenor-terrace, Glasgow.
1883. ‡Ferguson, Mrs. A. A. 11 Grosvenor-terrace, Glasgow.
1871. *FERGUSON, JOHN, M.A., LL.D., F.R.S.E., F.S.A., F.C.S., Professor of Chemistry in the University of Glasgow.
1867. ‡Ferguson, Robert M., LL.D., Ph.D., F.R.S.E. 5 Learmouth-terrace, Edinburgh.
1867. **Fergusson, H. B.* 13 *Airlie-place, Dundee.*
1883. ‡Fernald, H. P. Alma House, Cheltenham.
1883. *Fernie, John. Box No. 2, Hutchinson, Kansas, U.S.A.
1862. ‡FERRERS, Rev. NORMAN MACLEOD, D.D., F.R.S. Caius College Lodge, Cambridge.
1873. ‡FERRIER, DAVID, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College, London. 34 Cavendish-square, London, W.
1892. ‡Ferrier, Robert M., B.Sc. College of Science, Newcastle-upon-Tyne.
1882. §Fewings James, B.A., B.Sc. The Grammar School, Southampton.
1887. ‡Fiddes, Thomas, M.D. Penwood, Urmston, near Manchester.
1875. ‡Fiddes, Walter. Clapton Villa, Tyndall's Park, Clifton, Bristol.
1868. ‡Field, Edward. Norwich.
1886. ‡Field, H. C. 4 Carpenter-road, Edgbaston, Birmingham.
1869. *FIELD, ROGERS, B.A., M.Inst.C.E. 4 Westminster-chambers, Westminster, S.W.
1882. ‡Filliter, Freeland. St. Martin's House, Wareham, Dorset.
1883. *Finch, Gerard B., M.A. 1 St. Peter's-terrace, Cambridge.
Finch, John. Bridge Work, Chepstow.
1878. *Findlater, William. 22 Fitzwilliam-square, Dublin.

Year of Election.

1892. ‡Findlay, J. R., B.A. 3 Rothesay-terrace, Edinburgh.
1884. ‡Finlay, Samuel. Montreal, Canada.
1887. ‡Finnemore, Rev. J., M.A., Ph.D., F.G.S. 12 College-road, Brighton.
1881. ‡Firth, Colonel Sir Charles. Heckmondwike.
Firth, Thomas. Northwich.
1895. §Fish, Frederick J. Park-road, Ipswich.
1891. ‡Fisher, Major H. O. The Highlands, Llandough, near Cardiff.
1884. *Fisher, L. C. Galveston, Texas, U.S.A.
1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlton Rectory, near Cambridge.
1873. ‡Fisher, William. Maes Fron, near Welshpool, Montgomeryshire.
1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.
1858. ‡Fishwick, Henry. Carr-hill, Rochdale.
1887. *Fison, Alfred H., D.Sc. 14 Dean-road, Willesden Green, London, N.W.
1885. ‡Fison, E. Herbert. Stoke House, Ipswich.
1871. *FISON, FREDERICK W., M.A., F.C.S. Greenholme, Burley-in-Wharfedale, near Leeds.
1871. ‡FITCH, J. G., M.A., LL.D. 5 Lancaster-terrace, Regent's Park, London, N.W.
1883. ‡Fitch, Rev. J. J. Ivyholme, Southport.
1878. ‡Fitzgerald, C. E., M.D. 27 Upper Merrion-street, Dublin.
1878. §FITZGERALD, GEORGE FRANCIS, M.A., D.Sc., F.R.S., Professor of Natural and Experimental Philosophy in Trinity College, Dublin.
1885. *Fitzgerald, Professor Maurice, B.A. 69 Botanic-avenue, Belfast.
1894. §Fitzmaurice, M., M.Inst.C.E. Blackwall Tunnel Office, East Greenwich, London, S.E.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Baggot-street, Dublin.
1888. *FITZPATRICK, Rev. THOMAS C. Christ's College, Cambridge.
1865. ‡*Fleetwood, D. J. 45 George-street, St. Paul's, Birmingham.*
1881. ‡Fleming, Rev. Canon J., B.D. St. Michael's Vicarage, Ebury-square, London, S.W.
1876. ‡Fleming, James Brown. Beaconsfield, Kelvinside, near Glasgow.
1876. ‡Fleming, Sandford, C.M.G., F.G.S. Ottawa, Canada.
1867. §FLETCHER, ALFRED E., F.C.S. Delmore, Caterham, Surrey.
1870. ‡Fletcher, B. Edgington. Norwich.
1890. ‡Fletcher, B. Morley. 12 Trevor-square, London, S.W.
1892.§§Fletcher, George, F.G.S. 60 Connaught-avenue, Plymouth.
1869. ‡FLETCHER, LAVINGTON E., M.Inst.C.E. Alderley Edge, Cheshire.
1888. *FLETCHER, LAZARUS, M.A., F.R.S., F.G.S., F.C.S., Keeper of Minerals, British Museum (Natural History), Cromwell-road, London, S.W. 36 Woodville-road, Ealing, London, W.
1862. §FLOWER, Sir WILLIAM HENRY, K.C.B., LL.D., D.C.L., D.Sc., F.R.S., F.L.S., F.G.S., F.R.C.S., Director of the Natural History Departments, British Museum, South Kensington, London. 26 Stanhope-gardens, London, S.W.
1889. ‡Flower, Lady. 26 Stanhope-gardens, London, S.W.
1877. *Floyer, Ernest A., F.R.G.S., F.L.S. Downton, Salisbury.
1890. *Flux, A. W., M.A. Owens College, Manchester.
1887. ‡Foale, William. 3 Meadfoot-terrace, Mannamead, Plymouth.
1883. ‡Foale, Mrs. William. 3 Meadfoot-terrace, Mannamead, Plymouth.
1891. §Foldvary, William. Museum Ring, 10, Buda Pesth.
1879. ‡Foote, Charles Newth, M.D. 3 Albion-place, Sunderland.
1880. ‡Foote, R. Bruce, F.G.S. Care of Messrs. H. S. King & Co., 65 Cornhill, London, E.C.
1873. *FORBES, GEORGE, M.A., F.R.S., F.R.S.E., M.Inst.C.E. 34 Great George-street, London, S.W.

Year of Election.

1883. ‡FORBES, HENRY O., F.Z.S., Director of Museums for the Corporation of Liverpool. The Museum, Liverpool.
1885. ‡Forbes, The Right Hon. Lord. Castle Forbes, Aberdeenshire.
1890. ‡FORD, J. RAWLINSON. Quarry Dene, Weetwood-lane, Leeds.
1875. *FORDHAM, H. GEORGE, F.G.S. Odsey, Ashwell, Baldock, Herts.
1883. §Formby, R. Kirklake Bank, Formby, near Liverpool.
1894. §Forrest, Frederick. Castledown, Castle Hill, Hastings.
1887. ‡FORREST, Sir JOHN, K.C.M.G., F.R.G.S., F.G.S. Perth, Western Australia.
1867. ‡Forster, Anthony. Finlay House, St. Leonards-on-Sea.
1883. ‡FORSYTH, A. R., M.A., D.Sc., F.R.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge. Trinity College, Cambridge.
1884. ‡Fort, George H. Lakefield, Ontario, Canada.
1877. ‡FORTESCUE, The Right Hon. the Earl. Castle Hill, North Devon.
1882. ‡Forward, Henry. 10 Marine-avenue, Southend.
1870. ‡FORWOOD, Sir WILLIAM B. Ramleh, Blundellsands, Liverpool.
1875. ‡Foster, A. Le Neve. 51 Cadogan-square, London, S.W.
1865. ‡Foster, Sir B. Walter, M.D., M.P. 16 Temple-row, Birmingham.
1865. *FOSTER, CLEMENT LE NEVE, B.A., D.Sc., F.R.S., F.G.S., Professor of Mining in the Royal College of Science, London. Llandudno.
1883. ‡Foster, Mrs. C. Le Neve. Llandudno.
1857. *FOSTER, GEORGE CAREY, B.A., F.R.S., F.C.S., Professor of Physics in University College, London. 18 Daleham-gardens, Hampstead, London, N.W.
1877. §Foster, Joseph B. 6 James-street, Plymouth.
1859. *FOSTER, MICHAEL, M.A., M.D., LL.D., D.C.L., Sec.R.S., F.L.S., F.C.S., Professor of Physiology in the University of Cambridge. Shelford, Cambridge.
1863. ‡Foster, Robert. The Quarries, Grainger Park-road, Newcastle-upon-Tyne.
1866. ‡Fowler, George, M.Inst.C.E., F.G.S. Basford Hall, near Nottingham.
1868. ‡Fowler, G. G. Gunton Hall, Lowestoft, Suffolk.
1888. §Fowler, Gilbert J. Dalton Hall, Manchester.
1892. §Fowler, Miss Jessie A. 4 & 5 Imperial-buildings, Ludgate-circus, London, E.C.
1876. *Fowler, John. 16 Kerrsland-street, Hillhead, Glasgow.
1882. ‡FOWLER, Sir JOHN, Bart., K.C.M.G., M.Inst.C.E., F.G.S. 2 Queen Square-place, Westminster, S.W.
1884. ‡Fox, Miss A. M. Penjerrick, Falmouth.
1883. *Fox, Charles. 104 Ritherdon-road, Upper Tooting, London, S.W.
1883. §Fox, Sir CHARLES DOUGLAS, M.Inst.C.E. 28 Victoria-street, Westminster, S.W.
1883. ‡Fox, Howard, F.G.S. Falmouth.
1847. *Fox, Joseph Hoyland. The Cleve, Wellington, Somerset.
1888. ‡Fox, Thomas. Court, Wellington, Somerset.
1886. ‡Foxwell, Arthur, M.A., M.B. 17 Temple-row, Birmingham.
1881. *FOXWELL, HERBERT S., M.A., F.S.S., Professor of Political Economy in University College, London. St. John's College, Cambridge
1889. ‡Frain, Joseph, M.D. Grosvenor-place, Jesmond, Newcastle-upon-Tyne.
1884. ‡Francis, James B. Lowell, Massachusetts, U.S.A.
FRANCIS, WILLIAM, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, E.C.; and Manor House, Richmond, Surrey.
1845. ‡FRANKLAND, EDWARD, M.D., D.C.L., LL.D., Ph.D., F.R.S., F.C.S. The Yews, Reigate Hill, Surrey.

Year of Election.

1887. *FRANKLAND, PERCY F., Ph.D., B.Sc., F.R.S., Professor of Chemistry and Metallurgy in the Mason College, Birmingham.
1889. ‡Franklin, Rev. Canon. Clayton-street West, Newcastle-upon-Tyne.
1894. §Franklin, Mrs. E. L. 9 Pembridge-gardens, London, W.
1882. ‡Fraser, Alexander, M.B. Royal College of Surgeons, Dublin.
1885. ‡FRASER, ANGUS, M.A., M.D., F.C.S. 232 Union-street, Aberdeen.
1865. *FRASER, JOHN, M.A., M.D., F.G.S. Chapel Ash, Wolverhampton.
1871. ‡FRASER, THOMAS R., M.D., F.R.S., F.R.S.E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.
1859. *Frazer, Daniel. 127 Buchanan-street, Glasgow.
1871. ‡Frazer, Evan L. R. Brunswick-terrace, Spring Bank, Hull.
1884. *Frazer, Persifor, M.A., D.Sc. (Univ. de France). Room 1042, Drexel Building, Philadelphia, U.S.A.
1884. *FREAM, W., LL.D., B.Sc., F.L.S., F.G.S., F.S.S. The Vinery, Downton, Salisbury.
1877. §Freeman, Francis Ford. Abbotsfield, Tavistock, South Devon.
1884. *FREMANTLE, The Hon. Sir C. W., K.C.B. 10 Sloane-gardens, London, S.W.
1869. ‡Frere, Rev. William Edward. The Rectory, Bitton, near Bristol.
1886. ‡Freshfield, Douglas W., F.R.G.S. 1 Airlie-gardens, Campden Hill, London, W.
1887. ‡Fries, Harold H., Ph.D. 92 Reade-street, New York, U.S.A.
1887. ‡Froehlich, The Chevalier. Grosvenor-terrace, Withington, Manchester.
1892. *Frost, Edmund. The Elms, Lasswade, Midlothian.
1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.
1883. ‡Frost, Major H., J.P. West Wratting Hall, Cambridgeshire.
1887. *Frost, Robert, B.Sc. 53 Victoria-road, London, W.
1875. ‡Fry, F. J. 104 Pembroke-road, Clifton, Bristol.
1875. *Fry, Joseph Storrs. 13 Upper Belgrave-road, Clifton, Bristol.
1884. §Fryer, Joseph, J.P. Smelt House, Howden-le-Wear, Co. Durham.
1895. §Fullarton, Dr. J. H. Fishery Board for Scotland, George-street, Edinburgh.
1872. *Fuller, Rev. A. 7 Sydenham-hill, Sydenham, London, S.E.
1859. ‡FULLER, FREDERICK, M.A. 9 Palace-road, Surbiton.
1869. ‡FULLER, GEORGE, M.Inst.C.E. 71 Lexham-gardens, Kensington, London, W.
1884. §Fuller, William, M.B. Oswestry.
1891. ‡Fulton, Andrew. 23 Park-place, Cardiff.

1881. ‡Gabb, Rev. James, M.A. Bulmer Rectory, Welburn, Yorkshire.
1887. ‡Gaddum, G. H. Adria House, Toy-lane, Withington. Manchester.
1836. *Gadesden, Augustus William, F.S.A. Ewell Castle, Surrey.
1857. ‡GAGES, ALPHONSE, M.R.I.A. Museum of Irish Industry, Dublin.
1863. *Gainsford, W. D. Skendleby Hall, Spilsby.
1876. ‡Gairdner, Charles. Broom, Newton Mearns, Renfrewshire.
1850. ‡GAIRDNER, W. T., M.D., LL.D., F.R.S., Professor of Medicine in the University of Glasgow. The University, Glasgow.
1876. ‡Gale, James M. 23 Miller-street, Glasgow.
1863. ‡Gale, Samuel, F.C.S. 225 Oxford-street, London, W.
1885. *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.
1888. ‡Gallenga, Mrs. Anna. The Falls, Chepstow.
1888. ‡Gallenga, Mrs. A. A. R. The Falls, Chepstow.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1889. ‡Galloway, Walter. Eighton Banks, Gateshead.

Year of Election.

1875. ‡Galloway, W. Cardiff.
1887. *Galloway, W. The Cottage, Seymour-grove, Old Trafford, Manchester.
1860. *Galton, Sir Douglas, K.C.B., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. (President.) 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, M.A., D.C.L., D.Sc., F.R.S., F.G.S., F.R.G.S. 42 Rutland-gate, Knightsbridge, London, S.W.
1869. ‡Galton, John C., M.A., F.L.S. New University Club, St. James's-street, London, S.W.
1870. §Gamble, Lieut.-Colonel D., C.B. St. Helens, Lancashire.
1889. §§Gamble, David, jun. St. Helens, Lancashire.
1870. ‡Gamble, J. C. St. Helens, Lancashire.
1888. *Gamble, J. Sykes, M.A., F.L.S. Dehra Dún, North-West Provinces, India.
1877. ‡Gamble, William. St. Helens, Lancashire.
1868. ‡Gamgee, Arthur, M.D., F.R.S. Davos, Switzerland.
1889. ‡Gamgee, John. 6 Lingfield-road, Wimbledon, Surrey.
1883. ‡*Gant, Major John Castle. St. Leonards.*
1887. ‡Gardiner, Walter, M.A., F.R.S., F.L.S. 45 Hills-road, Cambridge.
1882. *Gardner, H. Dent, F.R.G.S. Fairmead, 46 The Goffs, Eastbourne.
1894. §§Gardner, J. Addyman. 5 Bath-place, Oxford.
1882. ‡Gardner, John Starkie, F.G.S. 29 Albert Embankment, London, S.E.
1884. ‡Garman, Samuel. Cambridge, Massachusetts, U.S.A.
1888. §§Garnett, Frederick Brooksbank, C.B., F.S.S. 4 Argyll-road, Kensington, London, W.
1887. *Garnett, Jeremiah. The Grange, near Bolton, Lancashire.
1882. ‡Garnett, William, D.C.L. London County Council, Spring-gardens, London, S.W.
1873. ‡Garnham, John. Hazelwood, Crescent-road, St. John's, Brockley, Kent, S.E.
1883. §Garson, J. G., M.D. 32 Duke-street, St. James's, London, S.W.
1894. §Garstang, Walter, M.A., F Z.S. Lincoln College, Oxford.
1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.
1882. ‡Garton, William. Woolston, Southampton.
1892. §Garvie, James. Devanha House, Bowes-road, New Southgate, London, N.
1889. ‡Garwood, E. J., B.A., F.G.S. Trinity College, Cambridge.
1870. ‡Gaskell, Holbrook. Woolton Wood, Liverpool.
1870. *Gaskell, Holbrook, jun. Clayton Lodge, Aigburth, Liverpool.
1862. *Gatty, Charles Henry, M.A., LL.D., F.R.S.E., F.L.S., F.G.S. Felbridge Place, East Grinstead, Sussex.
1890. ‡Gaunt, Sir Edwin. Carlton Lodge, Leeds.
1875. ‡Gavey, J. Hollydale, Hampton Wick, Middlesex.
1875. ‡Gaye, Henry S., M.D. Newton Abbot, Devon.
1892. ‡Geddes, George H. 8 Douglas-crescent, Edinburgh.
1871. ‡Geddes, John. 9 Melville-crescent, Edinburgh.
1883. ‡Geddes, John. 33 Portland-street, Southport.
1885. ‡Geddes, Professor Patrick. Ramsay-garden, Edinburgh.
1887. ‡Gee, W. W. Haldane. Owens College, Manchester.
1867. ‡Geikie, Sir Archibald, LL.D., D.Sc., F.R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom. 10 Chester-terrace, Regent's-park, London, N.W.
1871. ‡Geikie, James, LL.D., D.C.L., F.R.S., F.R.S.E., F.G.S., Murchison Professor of Geology and Mineralogy in the University of Edinburgh. 31 Merchiston-avenue, Edinburgh.

Year of Election.

1882. *GENESE, R. W., M.A., Professor of Mathematics in University College, Aberystwith.
1875. *George, Rev. Hereford B., M.A., F.R.G.S. New College, Oxford.
1885. ‡Gerard, Robert. Blair-Devenick, Cults, Aberdeen.
1884. *Gerrans, Henry T., M.A. Worcester College, Oxford.
1884. ‡Gibb, Charles. Abbotsford, Quebec, Canada.
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
1874. ‡Gibson, The Right Hon. Edward, Q.C. 23 Fitzwilliam-square, Dublin.
1892. §§Gibson, Francis Maitland. Care of Mrs. Main, 15 Leven-terrace, Edinburgh.
1876. *Gibson, George Alexander, M.D., D.Sc., F.R.S.E., Secretary to the Royal College of Physicians of Edinburgh. 17 Alva-street, Edinburgh.
1892. ‡*Gibson, James. 10 North Mansion House-road, Edinburgh.*
1884. ‡Gibson, Rev. James J. 183 Spadina-avenue, Toronto, Canada.
1885. ‡*Gibson, John, Ph.D. 15 Hartington-gardens, Edinburgh.*
1889. *Gibson, T. G. 2 Eslington-road, Newcastle-upon-Tyne.
1893. ‡Gibson, Walcot, F.G.S. 28 Jermyn-street, London, S.W.
1887. ‡GIFFEN, Sir ROBERT, K.C.B., LL.D., F.R.S., V.P.S.S. 44 Pembroke-road, London, S.W.
1888. *Gifford, H. J. Lyston Court, Tram Inn, Hereford.
1884. ‡Gilbert, E. E. 245 St. Antoine-street, Montreal, Canada.
1842. GILBERT, SIR JOSEPH HENRY, Ph.D., LL.D., F.R.S., F.C.S. Harpenden, near St. Albans.
1883. §§Gilbert, Lady. Harpenden, near St. Albans.
1857. ‡Gilbert, J. T., M.R.I.A. Villa Nova, Blackrock, Dublin.
1884. *Gilbert, Philip H. 24 Fort-street, Montreal, Canada.
1895. §Gilchrist, J. D. F. Carvenon, Anstruther, Scotland.
Gilderdale, Rev. John, M.A. Walthamstow, Essex.
1878. ‡Giles, Oliver. Crescent Villas, Bromsgrove.
Giles, Rev. William. Netherleigh House, near Chester.
1871. *GILL, DAVID, LL.D., F.R.S., F.R.A.S. Royal Observatory, Cape Town.
1888. §Gill, John Frederick. Douglas, Isle of Man.
1868. ‡Gill, Joseph. Palermo, Sicily. (Care of W. H. Gill, Esq., General Post Office, St. Martin's-le-Grand, E.C.)
1887. ‡Gillett, Charles Edwin. Wood Green, Banbury, Oxford.
1888. ‡Gilliland, E. T. 259 West Seventy-fourth-street, New York, U.S.A.
1884. ‡Gillman, Henry. 130 Lafayette-avenue, Detroit, Michigan, U.S.A.
1892. §Gilmour, Matthew A. B. Saffronhall House, Windmill-road, Hamilton, N.B.
1867. ‡Gilroy, Robert. Craigie, by Dundee.
1893. *Gimingham, Edward. Stamford House, Northumberland Park, Tottenham, London.
1867. ‡GINSBURG, Rev. C. D., D.C.L., LL.D. Holmlea, Virginia Water Station, Chertsey.
1884. ‡Girdwood, Dr. G. P. 28 Beaver Hall-terrace, Montreal, Canada.
1874. *Girdwood, James Kennedy. Old Park, Belfast.
1886. *Gisborne, Hartley. Qu'Appelle Station, Assa, N.-W.T., Canada.
1883. *Gladstone, Miss. 17 Pembridge-square, London, W.
1883. *Gladstone, Miss E. A. 17 Pembridge-square, London, W.
1850. *Gladstone, George, F.C.S., F.R.G.S. 34 Denmark-villas, Hove, Brighton.
1849. *GLADSTONE, JOHN HALL, Ph.D., D.Sc., F.R.S., F.C.S. 17 Pembridge-square, London, W.

Year of Election.

1890. *Gladstone, Miss Margaret E. 17 Pembridge-square, London, W.
1861. *GLAISHER, JAMES, F.R.S., F.R.A.S. The Shola, Heathfield-road, South Croydon.
1871. *GLAISHER, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. Trinity College, Cambridge.
1883. ‡Glasson, L. T. 2 Roper-street, Penrith.
1881. *GLAZEBROOK, R. T., M.A., F.R.S. 7 Harvey-road, Cambridge.
1881. *Gleadow, Frederic. 84 Kensington Park-road, London, W.
1859. ‡Glennie, J. S. Stuart, M.A. Verandah Cottage, Haslemere, Surrey.
1867. ‡Gloag, John A. L. 10 Inverleith-place, Edinburgh.
Glover, George. Ranelagh-road, Pimlico, London, S.W.
1874. ‡Glover, George T. 30 Donegall-place, Belfast.
Glover, Thomas. 124 Manchester-road, Southport.
1870. ‡Glynn, Thomas R., M.D. 62 Rodney-street, Liverpool.
1889. ‡Goddard, F. R. 19 Victoria-square, Newcastle-upon-Tyne.
1872. ‡GODDARD, RICHARD. 16 Booth-street, Bradford, Yorkshire.
1886. ‡Godlee, Arthur. The Lea, Harborne, Birmingham.
1887. ‡Godlee, Francis. 8 Minshall-street, Manchester.
1878. *Godlee, J. Lister. Whip's Cross, Walthamstow.
1880. ‡GODMAN, F. DU CANE, F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, London, W.
1883. ‡Godson, Dr. Alfred. Cheadle, Cheshire.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1879. §GODWIN-AUSTEN, Lieut.-Colonel H. H., F.R.S., F.G.S., F.R.G.S., F.Z.S. Shalford House, Guildford.
1876. ‡Goff, Bruce, M.D. Bothwell, Lanarkshire.
1881. ‡GOLDSCHMIDT, EDWARD, J.P. Nottingham.
1886. ‡GOLDSMID, Major-General Sir F. J., C.B., K.C.S.I., F.R.G.S. Godfrey House, Hollingbourne.
1873. ‡*Goldthorp, Miss R. F. C. Cleckheaton, Bradford, Yorkshire.*
1890. *GONNER, E. C. K., M.A., Professor of Political Economy in University College, Liverpool.
1884. ‡Good, Charles E. 102 St. François Xavier-street, Montreal, Canada.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1878. ‡Goodbody, Jonathan, jun. 50 Dame-street, Dublin.
1884. ‡Goodbody, Robert. Fairy Hill, Blackrock, Co. Dublin.
1886. ‡*Goodman, F. B. 46 Wheeley's-road, Edgbaston, Birmingham.*
1885. ‡GOODMAN, J. D., J.P. Peachfield, Edgbaston, Birmingham.
1884. *Goodridge, Richard E. W. 1030 The Rookery Building, Chicago, Illinois, U.S.A.
1884. ‡Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1883. ‡Goouch, B., B.A. 2 Oxford-road, Birkdale, Southport.
1885. ‡Gordon, General the Hon. Sir Alexander Hamilton. 50 Queen's Gate-gardens, London, S.W.
1885. ‡Gordon, Rev. Cosmo, D.D., F.R.A.S., F.G.S. Chetwynd Rectory, Newport, Salop.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's Mansions, Westminster, S.W.
1884. *Gordon, Robert, M.Inst.C.E., F.R.G.S. 8 St. Mary-street, St. Andrews, N.B.
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1885. ‡Gordon, Rev. William. Braemar, N.B.
1887. ‡Gordon, William John. 3 Lavender-gardens, London, S.W.
1865. ‡GORE, GEORGE, LL.D., F.R.S. 67 Broad-street, Birmingham.
1875. *GOTCH, FRANCIS, B.A., B.Sc., F.R.S., Professor of Physiology in the University of Oxford.

Year of Election.

1873. ‡Gott, Charles, M.Inst.C.E. Parkfield-road, Manningham, Bradford, Yorkshire.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1881. ‡Gough, Thomas, B.Sc., F.C.S. Elmfield College, York.
1894. §§Gould, G. M. 119 South 17th-street, Philadelphia, U.S.A.
1888. ‡Gouraud, Colonel. Little Menlo, Norwood, Surrey.
1873. ‡*Gourlay, J. McMillan. 21 St. Andrew's-place, Bradford, Yorkshire.*
1867. ‡Gourley, Henry (Engineer). Dundee.
1876. ‡Gow, Robert. Cairndowan, Dowanhill, Glasgow.
1883. §Gow, Mrs. Cairndowan, Dowanhill, Glasgow.
1873. §Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1886. ‡Grabham, Michael C., M.D. Madeira.
1875. ‡GRAHAME, JAMES. 12 St. Vincent-street, Glasgow.
1892. §Grange, C. Ernest. Royal Grammar School, Lancaster.
1893. ‡Granger, F. S., M.A., D.Litt. 2 Cranmer-street, Nottingham.
1892. §§Grant, W. B. 10 Ann-street, Edinburgh.
1864. ‡Grantham, Richard F., F.G.S. Northumberland-chambers, Northumberland-avenue, London, W.C.
1881. ‡Gray, Alan, LL.B. Minster-yard, York.
1890. ‡Gray, Professor Andrew, M.A., F.R.S.E. University College, Bangor.
1864. *Gray, Rev. Canon Charles. The Vicarage, Blyth, Rotherham.
1865. ‡Gray, Charles. Swan Bank, Bilston.
1876. ‡Gray, Dr. Newton-terrace, Glasgow.
1881. ‡Gray, Edwin, LL.B. Minster-yard, York.
1893. §§Gray, J. C., General Secretary of the Co-operative Union, Limited, Long Millgate, Manchester.
1892. *Gray, James H., M.A., B.Sc. The University, Glasgow.
1892. §Gray, John. 351 Clarewood-terrace, Brixton, London, S.W.
1887. §§Gray, Joseph W., F.G.S. Cleveland Villa, Shurdington Road, Cheltenham.
1887. ‡Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.
1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.
1881. ‡Gray, Thomas, Professor of Engineering in the Rane Technical Institute, Terre Haute, Indiana, U.S.A.
1873. ‡Gray, William, M.R.I.A. 8 Mount Charles, Belfast.
*GRAY, Colonel WILLIAM. Farley Hall, near Reading.
1883. ‡Gray, William Lewis. 36 Gutter-lane, London, E.C.
1883. ‡Gray, Mrs. W. L. 36 Gutter-lane, London, E.C.
1886. ‡Greaney, Rev. William. Bishop's House, Bath-street, Birmingham.
1883. ‡Greathead, J. H., M.Inst.C.E. 15 Victoria-street, London, S.W.
1866. §Greaves, Charles Augustus, M.B., LL.B. 84 Friar-gate, Derby.
1893. *Greaves, Mrs. Elizabeth. Station-street, Nottingham.
1869. ‡Greaves, William. Station-street, Nottingham.
1872. ‡Greaves, William. 33 Marlborough-place, London, N.W.
1872. *Grece, Clair J., LL.D. Redhill, Surrey.
1889. ‡GREEN, A. H., M.A., F.R.S., F.G.S., Professor of Geology in the University of Oxford. 137 Woodstock-road, Oxford.
1888. §GREEN, JOSEPH R., M.A., B.Sc., F.R.S., F.L.S., Professor of Botany to the Pharmaceutical Society of Great Britain. 17 Bloomsbury-square, London, W.C.
1887. ‡Greene, Friese. 162 Sloane-street, London, S.W.
1887. ‡Greenhalgh, Richard. 1 Temple-gardens, The Temple, London, E.C.
1858. *Greenhalgh, Thomas. Thornydikes, Sharples, near Bolton-le-Moors.

Year of Election.

1882. ‡GREENHILL, A. G., M.A., F.R.S., Professor of Mathematics in the Royal Artillery College, Woolwich. 10 New Inn, London, W.C.
1881. §Greenhough, Edward. Matlock Bath, Derbyshire.
1884. ‡Greenish, Thomas, F.C.S. 20 New-street, Dorset-square, London, N.W.
1884. ‡Greenshields, E. B. Montreal, Canada.
1884. ‡Greenshields, Samuel. Montreal, Canada.
1887. ‡Greenwell, G. C., jun. Driffield, near Derby.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1889. ‡*Greenwell, T. G. Woodside, Sunderland.*
1890. ‡Greenwood, Arthur. Cavendish-road, Leeds.
1877. ‡Greenwood, Holmes. 78 King-street, Accrington.
1849. ‡Greenwood, William. Stones, Todmorden.
1887. §§Greenwood, W. H., M.Inst.C.E. Adderley Park Rolling Mills, Birmingham.
1887. *Greg, Arthur. Eagley, near Bolton, Lancashire.
1861. *GREG, ROBERT PHILIPS, F.G.S., F.R.A.S. Coles Park, Buntingford, Herts.
1860. ‡GREGOR, Rev. WALTER, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1868. ‡Gregory, Sir Charles Hutton, K.C.M.G., M.Inst.C.E. 2 Delahay-street, Westminster, S.W.
1894. §§Gregory, J. Walter, D.Sc., F.G.S. British Museum, Cromwell-road, London, S.W.
1883. ‡Gregson, G. E. Ribble View, Preston.
1881. ‡Gregson, William, F.G.S. Baldersby, S.O., Yorkshire.
1859. ‡GRIERSON, THOMAS BOYLE, M.D. Thornhill, Dumfriesshire.
1870. ‡Grieve, John, M.D. Care of W. L. Buchanan, Esq., 212 St. Vincent-street, Glasgow.
1878. ‡Griffin, Robert, M.A., LL.D. Trinity College, Dublin.
Griffin, S. F. Albion Tin Works, York-road, London, N.
1894. *Griffith, C. L. T. College-road, Harrow, Middlesex.
1894. *Griffith, Miss F. H. College-road, Harrow, Middlesex.
1859. *GRIFFITH, GEORGE, M.A. (ASSISTANT GENERAL SECRETARY.) College-road, Harrow, Middlesex.
1870. ‡Griffith, Rev. Henry. Brooklands, Isleworth, Middlesex.
1884. ‡GRIFFITHS, E. H., F.R.S. 12 Park-side, Cambridge.
1884. ‡Griffiths, Mrs. 12 Park-side, Cambridge.
1891. ‡Griffiths, P. Rhys, B.Sc., M.B. 71 Newport-road, Cardiff.
1847. ‡Griffiths, Thomas. The Elms, Harborne-road, Edgbaston, Birmingham.
1870. ‡Grimsdale, T. F., M.D. Hoylake, Liverpool.
1888. *Grimshaw, James Walter. Australian Club, Sydney, New South Wales.
1884. ‡Grinnell, Frederick. Providence, Rhode Island, U.S.A.
1881. ‡Gripper, Edward. Mansfield-road, Nottingham.
1894. §§Groom, P., M.A., F.L.S. 38 Regent-street, Oxford.
1894. §§Groom, T. T. The Poplars, Hereford.
1892. ‡Grove, Mrs. Lilly, F.R.G.S. Mason College, Birmingham.
GROVE, The Right Hon. Sir WILLIAM ROBERT, Knt., M.A., D.C.L., LL.D., F.R.S. 115 Harley-street, London, W.
1891. ‡Grover, Henry Llewellin. Clydach Court, Pontypridd.
1863. *GROVES, THOMAS B., F.C.S. 80 St. Mary-street, Weymouth.
1869. ‡GRUBB, Sir HOWARD, F.R.S., F.R.A.S. 51 Kenilworth-square, Rathgar, Dublin.
1886. ‡Grundy, John. 17 Private-road, Mapperley, Nottingham.

Year of Election.

1891. ‡Grylls, W. London and Provincial Bank, Cardiff.
1887. ‡GUILLEMARD, F. H. H. Eltham, Kent.
Guinness, Henry. 17 College-green, Dublin.
1842. Guinness, Richard Seymour. 17 College-green, Dublin.
1885. ‡Gunn, John. 4 Parkside-terrace, Edinburgh.
1891. ‡Gunn, John. Llandaff House, Llandaff.
1877. ‡Gunn, William, F.G.S. Office of the Geological Survey of Scotland, Sheriff's Court House, Edinburgh.
1866. ‡GÜNTHER, ALBERT C. L. G., M.A., M.D., Ph.D., F.R.S., F.Z.S. 23 Litchfield-road, Kew, Surrey.
1894. §§Günther, R. T. Magdalen College, Oxford.
1880. §Guppy, John J. Ivy-place, High-street, Swansea.
1876. ‡Guthrie, Francis. Cape Town, Cape of Good Hope.
1883. ‡Guthrie, Malcolm. Prince's-road, Liverpool.
1857. ‡Gwynne, Rev. John. Tullyagnish, Letterkenny, Strabane, Ireland.
1876. ‡GWYTHER, R. F., M.A. Owens College, Manchester.

1884. ‡Haanel, E., Ph.D. Cobourg, Ontario, Canada.
1887. ‡Hackett, Henry Eugene. Hyde-road, Gorton, Manchester.
1865. ‡*Hackney, William. 9 Victoria-chambers, Victoria-street, London, S.W.*
1884. ‡Hadden, Captain C. F., R.A. Woolwich.
1881. *HADDON, ALFRED CORT, B.A., F.Z.S. Inisfail, Hills-road, Cambridge.
1842. Hadfield, George. Victoria-park, Manchester.
1888. *Hadfield, R. A. The Grove, Sheffield.
1892. §§Haigh, E., M.A. Longton, Staffordshire.
1870. ‡Haigh, George. 27 Highfield South, Rock Ferry, Cheshire.
1879. ‡HAKE, H. WILSON, Ph.D., F.C.S. Queenwood College, Hants.
1887. ‡Hale, The Hon. E. J. 9 Mount-street, Manchester.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1883. **Hall, Miss Emily. Burlington House, Spring Grove, Isleworth, Middlesex.*
1881. ‡Hall, Frederick Thomas, F.R.A.S. 15 Gray's Inn-square, London, W.C.
1854. *HALL, HUGH FERGIE, F.G.S. Staverton House, Woodstock-road, Oxford.
1887. ‡Hall, John. Springbank, Leftwich, Northwich.
1872. *Hall, Captain Marshall, F.G.S. Easterton Lodge, Parkstone R.S.O., Dorset.
1885. §Hall, Samuel. 19 Aberdeen Park, Highbury, London, N.
1884. ‡Hall, Thomas Proctor. School of Practical Science, Toronto, Canada.
1866. *HALL, TOWNSHEND M., F.G.S. Orchard House, Pilton, Barnstaple.
1891. *Hallett, George. Cranford, Victoria-road, Penarth, Glamorganshire.
1891. §Hallett, J. H., M.Inst.C.E. Maindy Lodge, Cardiff.
1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.
1888. §HALLIBURTON, W. D., M.D., F.R.S., Professor of Physiology in King's College, London. 9 Ridgmount-gardens, Gower-street, London, W.C.
Halsall, Edward. 4 Somerset-street, Kingsdown, Bristol.
1886. ‡*Hambleton, G. W. 23 Bryanston-street, Portman-square, London, W.*
1858. *Hambly, Charles Hambly Burbridge, F.G.S. Holmeside, Hazelwood, Derby.
1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.
1885. ‡Hamilton, David James. 1A Albyn-place, Aberdeen.
1869. ‡Hamilton, Rowland. Oriental Club, Hanover-square, London, W.
1851. ‡*Hammond, C. C. Lower Brook-street, Ipswich.*
1881. *Hammond, Robert. 18 Dickinson-road, Crouch End, London, N.

Year of Election.

1892. ‡Hanbury, Thomas, F.L.S. La Mortola, Ventimiglia, Italy.
1878. ‡Hance, Edward M., LL.B. Municipal Buildings, Liverpool.
1875. ‡Hancock, C. F., M.A. 125 Queen's-gate, London, S.W.
1861. ‡Hancock, Walter. 10 Upper Chadwell-street, Pentonville, London, E.C.
1890. ‡Hankin, Ernest Hanbury. St. John's College, Cambridge.
1882. ‡Hankinson, R. C. Bassett, Southampton.
1884.§§Hannaford, E. P. 2573 St. Catherine-street, Montreal, Canada.
1894. §Hannah, Robert, F.G.S. 82 Addison-road, London, W.
1859. ‡*Hannay, John. Montcoffer House, Aberdeen.*
1886. §Hansford, Charles. 3 Alexandra-terrace, Dorchester.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., F.R.S., Pres.C.S. (GENERAL SECRETARY.) Cowley Grange, Oxford.
1890. *HARCOURT, L. F. VERNON, M.A., M.Inst.C.E. 6 Queen Anne's-gate, London, S.W.
1886. *Hardcastle, Basil W., F.S.S. 12 Gainsborough-gardens, Hampstead, London, N.W.
1892. *Harden, Arthur, Ph.D., M.Sc. Ashville, Upper Chorlton-road, Manchester.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1869. ‡Harding, Joseph. Millbrook House, Exeter.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1869. ‡Harding, William D. Islington Lodge, King's Lynn, Norfolk.
1894.§§Hardman, S. C. 225 Lord-street, Southport.
1894.§§Hare, A. T., M.A. Neston Lodge, East Twickenham, Middlesex.
1894.§§Hare, Mrs. Neston Lodge, East Twickenham, Middlesex.
1838. *HARE, CHARLES JOHN, M.D. Berkeley House, 15 Manchester-square, London, W.
1858. ‡Hargrave, James. Burley, near Leeds.
1883. ‡Hargreaves, Miss H. M. 69 Alexandra-road, Southport.
1883. ‡Hargreaves, Thomas. 69 Alexandra-road, Southport.
1890. ‡Hargrove, Rev. Charles. 10 De Grey-terrace, Leeds.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York.
1890. §HARKER, ALFRED, M.A., F.G.S. St. John's College, Cambridge.
1887. ‡Harker, T. H. Brook House, Fallowfield, Manchester.
1878. *Harkness, H. W., M.D. California Academy of Sciences, San Francisco, California, U.S.A.
1871. ‡Harkness, William, F.C.S. Laboratory, Somerset House, London, W.C.
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton, Sussex.
1883. *Harley, Miss Clara. The Quintic, Savile Park, Halifax, Yorkshire.
1862. *HARLEY, GEORGE, M.D., F.R.S., F.C.S. 25 Harley-street, London, W.
1883. *Harley, Harold. 14 Chapel-street, Bedford-row, London, W.C.
1862. *HARLEY, Rev. ROBERT, M.A., F.R.S., F.R.A.S. The Quintic, Savile Park, Halifax, Yorkshire.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., B.Sc. King's College, Cambridge.
1882. ‡Harper, G. T. Bryn Hyfrydd, Portswood, Southampton.
1872. ‡Harpley, Rev. William, M.A. Clayhanger Rectory, Tiverton.
1884. ‡Harrington, B. J., B.A., Ph.D., F.G.S., Professor of Chemistry and Mineralogy in McGill University, Montreal. Wallbrac-place, Montreal, Canada.
1872. *Harris, Alfred. Lunefield, Kirkby Lonsdale, Westmoreland.

Year of Election.

1888. ‡Harris, C. T. 4 Kilburn Priory, London, N.W.
1842. *Harris, G. W., M.Inst.C.E. Moray-place, Dunedin, New Zealand.
1889. §HARRIS, H. GRAHAM, M.Inst.C.E. 5 Great George-street, Westminster, S.W.
1884. ‡Harris, Miss Katherine E. 73 Albert Hall-mansions, Kensington-gore, London, S.W.
1888. ‡Harrison, Charles. 20 Lennox-gardens, London, S.W.
1860. ‡Harrison, Rev. Francis, M.A. North Wraxall, Chippenham.
1864. ‡Harrison, George. Barnsley, Yorkshire.
1874. ‡Harrison, G. D. B. 3 Beaufort-road, Clifton, Bristol.
1858. *HARRISON, JAMES PARK, M.A. 22 Connaught-street, Hyde Park, London, W.
1892. ‡HARRISON, JOHN. Rockville, Napier-road, Edinburgh.
1889. §Harrison, J. C. Oxford House, Castle-road, Scarborough.
1870. ‡HARRISON, REGINALD, F.R.C.S. 6 Lower Berkeley-street, Portman-square, London, W.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1892. ‡Harrison, Rev. S. N. Ramsay, Isle of Man.
1895. §Harrison, Thomas. 48 High-street, Ipswich.
1886. ‡Harrison, W. Jerome, F.G.S. Board School, Icknield-street, Birmingham.
1885. ‡*Hart, Charles J. 10 Calthorpe-road, Edgbaston, Birmingham.*
1876. *Hart, Thomas. Brooklands, Blackburn.
1875. ‡Hart, W. E. Kilderry, near Londonderry.
1893. *Hartland, E. Sidney, F.S.A. Highgarth, Gloucester.
Hartley, James. Sunderland.
1871. ‡HARTLEY, WALTER NOEL, F.R.S., F.R.S.E., F.C.S., Professor of Chemistry in the Royal College of Science, Dublin. 36 Waterloo-road, Dublin.
1890. **Hartnell, Wilson. 8 Blenheim-terrace, Leeds.*
1886. *HARTOG, Professor M. M., D.Sc. Queen's College, Cork.
1887. §§Hartog, P. J., B.Sc. Owens College, Manchester.
1885. §§Harvie-Brown, J. A. Dunipace, Larbert, N.B.
1862. *Harwood, John. Woodside Mills, Bolton-le-Moors.
1884. ‡Haslam, Rev. George, M.A. Trinity College, Toronto, Canada.
1882. ‡Haslam, George James, M.D. Owens College, Manchester.
1893. §Haslam, Lewis. Ravenswood, near Bolton, Lancashire.
1875. *HASTINGS, G. W. 23 Kensington-square, London, W.
1889. ‡Hatch, F. H., Ph.D., F.G.S. 28 Jermyn-street, London, S.W.
1893. ‡Hatton, John L. S. People's Palace, Mile End-road, London, E.
1857. ‡HAUGHTON, Rev. SAMUEL, M.A., M.D., D.C.L., LL.D., F.R.S., M.R.I.A., F.G.S., Senior Fellow of Trinity College, Dublin. Trinity College, Dublin.
1887. *Hawkins, William. Earlston House, Broughton Park, Manchester.
1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, London, S.W.
1864. *HAWKSHAW, JOHN CLARKE, M.A., M.Inst.C.E., F.G.S. 2 Down-street, W., and 33 Great George-street, London, S.W.
1884. *Haworth, Abraham. Hilston House, Altrincham.
1889. ‡Haworth, George C. Ordsal, Salford.
1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.
1887. ‡Haworth, S. E. Warsley-road, Swinton, Manchester.
1886. ‡Haworth, Rev. T. J. Albert Cottage, Saltley, Birmingham.
1890. ‡Hawtin, J. N. Sturdie House, Roundhay-road, Leeds.
1877. ‡Hay, Arthur J. Lerwick, Shetland.
1861. *HAY, Admiral the Right Hon. Sir JOHN C. D., Bart., K.C.B., D.C.L., F.R.S. 108 St. George's-square, London, S.W.

Year of Election.

1885. *Haycraft, John Berry, M.D., B.Sc., F.R.S.E. University College, Cardiff.
1891. ‡Hayde, Rev. J. St. Peter's, Cardiff.
1894. §§Hayes, Edward Harold. 5 Rawlinson-road, Oxford.
1873. *Hayes, Rev. William A., M.A. Dromore, Co. Down, Ireland.
1858. *HAYWARD, ROBERT BALDWIN, M.A., F.R.S. Ashcombe, Shanklin, Isle of Wight.
1888. ‡*Hazard, Rowland R. Little Mulgrave House, Hurlingham.*
1851. §HEAD, JEREMIAH, M.Inst.C.E., F.C.S. 47 Victoria-street, Westminster, S.W.
1883. ‡Headley, Frederick Halcombe. Manor House, Petersham, S.W.
1883. ‡Headley, Mrs. Marian. Manor House, Petersham, S.W.
1883. §Headley, Rev. Tanfield George. Manor House, Petersham, S.W.
1871. §Healey, George. Brantfield, Bowness, Windermere.
1883. *Heap, Ralph, jun. 1 Brick-court, Temple, London, E.C.
1861. *Heape, Benjamin. Northwood, Prestwich, Manchester.
1883. ‡Heape, Charles. Tovrak, Oxton, Cheshire.
1883. ‡Heape, Joseph R. 96 Tweedale-street, Rochdale.
1882. *Heape, Walter, M.A. St. Mary's, Trumpington, Cambridge.
1877. ‡Hearder, Henry Pollington. Westwell-street, Plymouth.
1877. ‡Hearder, William Keep, F.S.A. 195 Union-street, Plymouth.
1883. ‡Heath, Dr. 46 Hoghton-street, Southport.
1866. ‡Heath, Rev. D. J. Esher, Surrey.
1884. ‡Heath, Thomas, B.A. Royal Observatory, Edinburgh.
1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.
1886. ‡Heaton, Miss Ellen. Woodhouse-square, Leeds.
1865. ‡Heaton, Harry. Harborne House, Harborne, Birmingham.
1892. *HEATON, WILLIAM H., M.A., Professor of Physics in University College, Nottingham.
1889. *Heaviside, Arthur West. 7 Grafton-road, Whitley, Newcastle-upon-Tyne.
1884. §Heaviside, Rev. George, B.A., F.R.G.S., F.R.Hist.S. 7 Grosvenor-street, Coventry.
1833. ‡HEAVISIDE, Rev. Canon J. W. L., M.A. The Close, Norwich.
1888. *Heawood, Edward, B.A. Skelwith Bridge, Ambleside.
1888. *Heawood, Percy Y., Lecturer in Mathematics at Durham University. 41 Old Elvet, Durham.
1855. ‡HECTOR, Sir JAMES, K.C.M.G., M.D., F.R.S., F.G.S., Director of the Geological Survey of New Zealand. Wellington, New Zealand.
1867. ‡Heddle, M. Forster, M.D., F.R.S.E. St. Andrews, N.B.
1882. ‡*Hedger, Philip. Cumberland-place, Southampton.*
1887. *HEDGES, KILLINGWORTH, M.Inst.C.E. 92 Victoria-street, London, S.W.
1863. ‡*Hedley, Thomas. Cox Lodge, near Newcastle-upon-Tyne.*
1881. *HELE-SHAW, H. S., M.Inst.C.E., Professor of Engineering in University College, Liverpool. 20 Waverley-road, Liverpool.
1887. §Hembry, Frederick William, F.R.M.S. Sussex Lodge, Sidcup, Kent.
1867. ‡Henderson, Alexander. Dundee.
1873. *Henderson, A. L. 277 Lewisham High-road, London, S.E.
1883. ‡Henderson, Mrs. A. L. 277 Lewisham High-road, London, S.E.
1891. *HENDERSON, G. G., D.Sc., M.A., F.C.S., F.I.C., Professor of Chemistry in the Glasgow and West of Scotland Technical College. 204 George-street, Glasgow.
1892. ‡Henderson, John. 3 St. Catherine-place, Grange, Edinburgh.
1880. *Henderson, Captain W. H., R.N. 21 Albert Hall-mansions, London, S.W.
1885. ‡Henderson, Sir William. Devanha House, Aberdeen.

Year of Election.

1892. §Henigan, Richard. Alma-road, The Avenue, Southampton.

1856. ‡HENNESSY, HENRY G., F.R.S., M.R.I.A. 81 Marlborough-road, Dublin.

1873. *HENRICI, OLAUS M. F. E., Ph.D., F.R.S., Professor of Mechanics and Mathematics in the City and Guilds of London Institute. Central Institution, Exhibition-road, London, S.W. 34 Clarendon-road, Notting Hill, W.

Henry, Franklin. Portland-street, Manchester.

Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.

Henry, Mitchell. Stratheden House, Hyde Park, London, W.

1884. ‡Henshaw, George H. 43 Victoria-street, Montreal, Canada.

1892. ‡Hepburn, David, M.D., F.R.S.E. The University, Edinburgh.

1855. *Hepburn, J. Gotch, LL.B., F.C.S. Oakfield Cottage, Dartford, Kent.

1855. ‡Hepburn, Robert. 9 Portland-place, London, W.

1890. ‡Hepper, J. 43 Cardigan-road, Headingley, Leeds.

1890. ‡Hepworth, Joseph. 25 Wellington-street, Leeds.

1892. *Herbertson, Andrew J. University Hall, Edinburgh.

1887. *HERDMAN, WILLIAM A., D.Sc., F.R.S., F.R.S.E., F.L.S. (LOCAL SECRETARY), Professor of Natural History in University College, Liverpool.

1893. *Herdman, Mrs. 32 Bentley-road, Liverpool.

1891. ‡Hern, S. South Cliff, Marine Parade, Penarth.

1871. *HERSCHEL, ALEXANDER S., M.A., D.C.L., F.R.S., F.R.A.S., Honorary Professor of Physics and Experimental Philosophy in the University of Durham College of Science, Newcastle-upon-Tyne. Observatory House, Slough, Bucks.

1874. §HERSCHEL, Colonel JOHN, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.

1895. §Hesketh, James. Scarisbrick Avenue-buildings, 107 Lord-street, Southport.

1894. §HEWETSON, G. H. 39 Henley-road, Ipswich.

1890. ‡Hewetson, H. Bendelack, M.R.C.S., F.L.S. 11 Hanover-square, Leeds.

1884. §Hewett, George Edwin. Cotswold House, St. John's Wood Park, London, N.W.

1894. §§Hewins, W. A. S., M.A., F.S.S. 26 Cheyne-row, Chelsea, London, S.W.

1893. §§Hewitt, Thomas P. Eccleston Park, Prescot, Lancashire.

1883. ‡Hewson, Thomas. Care of J. C. C. Payne, Esq., Botanic-avenue, The Plains, Belfast.

1881. ‡Hey, Rev. William Croser, M.A. Clifton, York.

1882. ‡Heycock, Charles T., B.A., F.R.S. King's College, Cambridge.

1883. ‡Heyes, Rev. John Frederick, M.A., F.C.S., F.R.G.S. Crowell, Tetsworth, Oxford.

1866. *Heymann, Albert. West Bridgford, Nottinghamshire.

1879. ‡Heywood, A. Percival. Duffield Bank, Derby.

1861. *Heywood, Arthur Henry. Elleray, Windermere.

1886. §HEYWOOD, HENRY, J.P., F.C.S. Witla Court, near Cardiff.

1833. *HEYWOOD, JAMES, F.R.S., F.G.S., F.S.A., F.R.G.S., F.S.S. 26 Kensington Palace-gardens, London, W.

1887. ‡Heywood, Robert. Mayfield, Victoria Park, Manchester.

Heywood, Thomas Percival. Claremont, Manchester.

1888. ‡Hichens, James Harvey, M.A., F.G.S. The College, Cheltenham.

1881. §HICK, THOMAS, B.A., B.Sc. Brighton Grove, Rusholme, Manchester.

1875. ‡HICKS, HENRY, M.D., F.R.S., F.G.S. Hendon Grove, Hendon, Middlesex, N.W.

1877. §HICKS, Professor W. M., M.A., D.Sc., F.R.S., Principal of Firth College, Sheffield. Firth College, Sheffield.

Year of
Election.

1886. ‡Hicks, Mrs. W. M. Dunheved, Endcliffe-crescent, Sheffield.
1884. ‡Hickson, Joseph. 272 Mountain-street, Montreal, Canada.
1887. *Hickson, Sydney J., M.A., D.Sc., F.R.S., Professor of Zoology in Owens College, Manchester.
1864. *Hiern, W. P., M.A. Castle House, Barnstaple.
1875. ‡Higgins, Charles Hayes, M.D., M.R.C.P., F.R.C.S., F.R.S.E. Alfred House, Birkenhead.
1871. ‡Higgins, Clement, B.A., F.C.S. 5 Trebovir-road, Earl's Court, London, S.W.
1891. §Higgs, Henry, LL.B., F.S.S. 164 Brixton Hill, London, S.W.
Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.
1894. §Hill, Rev. A. Du Boulay. The Vicarage, Downton, Wilts.
1885. *Hill, Alexander, M.A., M.D. Downing College, Cambridge.
1872. §Hill, Charles, F.S.A. Rockhurst, West Hoathly, East Grinstead.
*Hill, Rev. Canon Edward, M.A., F.G.S. Sheering Rectory, Harlow.
1881. *Hill, Rev. Edwin, M.A., F.G.S. The Rectory, Cockfield, R.S.O., Suffolk.
1887. ‡Hill, G. H., F.G.S. Albert-chambers, Albert-square, Manchester.
1884. ‡Hill, Rev. James Edgar, M.A., B.D. 2488 St. Catherine-street, Montreal, Canada.
1886. ‡Hill, M. J. M., M.A., D.Sc., F.R.S., Professor of Pure Mathematics in University College, London.
1881. ‡Hill, Pearson. 50 Belsize Park, London, N.W.
1885. *Hill, Sidney. Langford House, Langford, Bristol.
1888. ‡Hill, William. Hitchin, Herts.
1876. ‡Hill, William H. Barlanark, Shettleston, N.B.
1885. *Hillhouse, William, M.A., F.L.S., Professor of Botany in Mason Science College, Birmingham. 95 Harborne-road, Edgbaston, Birmingham.
1886. §Hillier, Rev. E. J. Cardington Vicarage, Bedford.
1863. ‡Hills, F. C. Chemical Works, Deptford, Kent, S.E.
1887. ‡Hilton, Edwin. Oak Bank, Fallowfield, Manchester.
1858. ‡Hincks, Rev. Thomas, B.A., F.R.S. Stokeleigh, Leigh Woods, Clifton, Bristol.
1870. ‡Hinde, G. J., Ph.D., F.G.S. Avondale-road, Croydon, Surrey.
1883. *Hindle, James Henry. 8 Cobham-street, Accrington.
1888. *Hindmarsh, William Thomas, F.L.S. Alnbank, Alnwick.
1886. ‡Hingley, Sir Benjamin, Bart. Hatherton Lodge, Cradley, Worcestershire.
1881. ‡Hingston, J. T. Clifton, York.
1884. ‡Hingston, William Hales, M.D., D.C.L. 37 Union-avenue, Montreal, Canada.
1884. ‡Hirschfilder, C. A. Toronto, Canada.
1890. *Hirst, James Andus. Adel Tower, Leeds.
1858. ‡Hirst, John, jun. Dobcross, near Manchester.
1884. ‡Hoadrey, John Chipman. Boston, Massachusetts, U.S.A.
Hoare, J. Gurney. Hampstead, London, N.W.
1881. §Hobbes, Robert George, M.R.I. Livingstone House, 374 Wandsworth-road, London, S.W.
1879. ‡Hobkirk, Charles P., F.L.S. West Riding Union Bank, Dewsbury.
1887. *Hobson, Bernard, B.Sc., F.G.S. Tapton Elms, Sheffield.
1883. ‡Hobson, Mrs. Carey. 5 Beaumont-crescent, West Kensington, London, W.
1883. ‡Hobson, Rev. E. W. 55 Albert-road, Southport.
1877. ‡Hockin, Edward. Poughill, Stratton, Cornwall.
1883. ‡Hocking, Rev. Silas K. 21 Scarisbrick New-road, Southport.

Year of Election.

1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1876. ‡Hodges, Frederick W. Queen's College, Belfast.
1852. ‡Hodges, John F., M.D., F.C.S., Professor of Agriculture in Queen's College, Belfast.
1863. *HODGKIN, THOMAS, B.A., D.C.L. Benwell Dene, Newcastle-upon-Tyne.
1887. *Hodgkinson, Alexander, M.B., B.Sc., Lecturer on Laryngology at Owens College, Manchester. 18 St. John-street, Manchester.
1880. §§Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., F.G.S., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 8 Park-villas, Blackheath, London, S.E.
1873. *Hodgson, George. Thornton-road, Bradford, Yorkshire.
1884. ‡Hodgson, Jonathan. Montreal, Canada.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. 7 Sandhill, Newcastle-upon-Tyne.
1894. §§Hogg, A. F. 134 Birchanger-road, South Norwood, London, S.E.
1894. §Holah, Ernest. 5 Crown-court, Cheapside, London, E.C.
1854. *Holcroft, George. Tyddyngwladis, Ganllwyd, near Dolgelly, North Wales.
1883. ‡Holden, Edward. Laurel Mount, Shipley, Yorkshire.
1873. *Holden, Sir Isaac, Bart. Oakworth House, near Keighley, Yorkshire.
1883. ‡Holden, James. 12 Park-avenue, Southport.
1883. ‡Holden, John J. 23 Duke-street, Southport.
1884. ‡Holden, Mrs. Mary E. Dunham Ladies' College, Quebec, Canada.
1887. *Holdsworth, C. J. Hill Top, near Kendal, Westmoreland.
1891. §§Holgate, Benjamin, F.G.S. Cardigan Villa, Grove-lane, Headingley, Leeds.
1879. ‡Holland, Calvert Bernard. Hazel Villa, Thicket-road, Anerley, London, S.E.
*Holland, Philip H. 3 Heath-rise, Willow-road, Hampstead, London, N.W.
1889. §Holländer, Bernard. King's College, Strand, London, W.C.
1886. ‡Holliday, J. R. 101 Harborne-road, Birmingham.
1865. ‡Holliday, William. New-street, Birmingham.
1883. ‡Hollingsworth, Dr. T. S. Elford Lodge, Spring Grove, Isleworth, Middlesex.
1883. *Holmes, Mrs. Basil. 5 Freeland-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. St. Helen's, Dennington Park-road, West Hampstead, London, N.W.
1892. ‡Holmes, Matthew. Netherby, Lenzie, Scotland.
1889. ‡*Holmes, Ralph, B.A. Hulme Grammar School, Manchester.*
1882. *HOLMES, THOMAS VINCENT, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1891. *Hood, Archibald, M.Inst.C.E. 42 Newport-road, Cardiff.
1875. *Hood, John. Chesterton, Cirencester.
1847. ‡HOOKER, Sir JOSEPH DALTON, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., F.R.G.S. The Camp, Sunningdale.
1892. §§Hooker, Reginald H., B.A. Royal Statistical Society, 9 Adelphi-terrace, London, W.C.
1865. *Hooper, John P. Coventry Park, Streatham, London, S.W.
1877. *Hooper, Rev. Samuel F., M.A. The Vicarage, Blackheath Hill, Greenwich, S.E.
1856. ‡Hooton, Jonathan. 116 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. 14 Airlie-gardens, Campden Hill, London, W.
1884. *Hopkins, Edward M. Orchard Dene, Henley-on-Thames.
1865. ‡Hopkins, J. S. Jesmond Grove, Edgbaston, Birmingham.
1884. *HOPKINSON, CHARLES. The Limes, Didsbury, near Manchester.
1882. *Hopkinson, Edward, M.A., D.Sc. Oakleigh, Timperley, Cheshire.

Year of Election.

1870. *Hopkinson, John, M.A., D.Sc., F.R.S. Holmwood, Wimbledon, Surrey.

1871. *Hopkinson, John, F.L.S., F.G.S., F.R.Met.Soc. 34 Margaret-street, Cavendish-square, London, W.; and The Grange, St. Albans.

1858. ‡Hopkinson, Joseph, jun. Britannia Works, Huddersfield.

1891. ‡Horder, T. Garrett. 10 Windsor-place, Cardiff.

Hornby, Hugh. Sandown, Liverpool.

1886. ‡*Horne, Edward H. Innisfail, Beulah Hill, Norwood, S.E.*

1885. ‡Horne, John, F.R.S.E., F.G.S. Geological Survey Office, Sheriff Court-buildings, Edinburgh.

1875. *Horniman, F. J., F.R.G.S., F.L.S. Surrey Mount, Forest Hill, London, S.E.

1884. *Horsfall, Richard. Stoodley House, Halifax.

1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.

1892. ‡*Horsley, Reginald E., M.B.* 46 *Heriot-row, Edinburgh.*

1893. *Horsley, Victor A. H., B.Sc., F.R.S., F.R.C.S., Professor of Pathology in University College, London. 25 Cavendish-square, London, W.

1884. *Hotblack, G. S. 52 Prince of Wales-road, Norwich.

1868. ‡*Hotson, W. C. Upper King-street, Norwich.*

1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.

1886. ‡Houghton, F. T. S., M.A., F.G.S. 188 Hagley-road, Edgbaston, Birmingham.

1887. ‡Houldsworth, Sir W. H., Bart., M.P. Norbury Booths, Knutsford.

1884. ‡Houston, William. Legislative Library, Toronto, Canada.

1883. *Hovenden, Frederick, F.L.S., F.G.S. Glenlea, Thurlow Park-road, West Dulwich, Surrey, S.E.

Hovenden, W. F., M.A. Bath.

1893. §Howard, F. T., B.A., F.G.S. University College, Cardiff.

1883. ‡Howard, James Fielden, M.D., M.R.C.S. Sandycroft, Shaw.

1886. *Howard, James L., D.Sc. 86 St. John's-road, Waterloo, near Liverpool.

1887. *Howard, S. S. 58 Albemarle-road, Beckenham, Kent.

1882. ‡Howard, William Frederick, Assoc.M.Inst.C.E. 13 Cavendish-street, Chesterfield, Derbyshire.

1886. ‡Howatt, David. 3 Birmingham-road, Dudley.

1876. ‡Howatt, James. 146 Buchanan-street, Glasgow.

1885. ‡Howden, James C., M.D. Sunnyside, Montrose, N.B.

1889. §Howden, Robert, M.B. University of Durham College of Medicine, Newcastle-upon-Tyne.

1857. ‡Howell, Henry H., F.G.S., Director of the Geological Survey of Great Britain. Geological Survey Office, Edinburgh.

1868. ‡Howell, Rev. Canon Hinds. Drayton Rectory, near Norwich.

1891. §Howell, Rev. William Charles, M.A., Vicar of Holy Trinity, High Cross, Tottenham, Middlesex.

1886. §Howes, Professor G. B., F.L.S. Royal College of Science, South Kensington, London, S.W.

1884. ‡Howland, Edward P., M.D. 211 41½-street, Washington, U.S.A.

1884. ‡Howland, Oliver Aiken. Toronto, Canada.

1865. *Howlett, Rev. Frederick, F.R.A.S. East Tisted Rectory, Alton, Hants.

1863. ‡Howorth, Sir H. H., K.C.I.E., M.P., D.C.L., F.R.S., F.S.A. Bentcliffe, Eccles, Manchester.

1883. ‡Howorth, John, J.P. Springbank, Burnley, Lancashire.

1883. ‡Hoyle, James. Blackburn.

1887. §Hoyle, William E., M.A. Owens College, Manchester.

1888. ‡Hudd, Alfred E., F.S.A. 94 Pembroke-road, Clifton, Bristol.

Year of Election.

1888. ‡HUDSON, C. T., M.A., LL.D., F.R.S. 2 Barton-crescent, Dawlish.
1894. §Hudson, John E. 125 Milk-street, Boston, Massachusetts, U.S.A.
1867. *HUDSON, WILLIAM H. H., M.A., Professor of Mathematics in King's College, London. 15 Altenberg-gardens, Clapham Common, London, S.W.
1858. *HUGGINS, WILLIAM, D.C.L. Oxon., LL.D. Camb., F.R.S., F.R.A.S. 90 Upper Tulse Hill, Brixton, London, S.W.
1892. ‡*Hughes, Alfred W. Woodside, Musselburgh.*
1887. ‡Hughes, E. G. 4 Roman-place, Higher Broughton, Manchester.
1883. ‡Hughes, Miss E. P. Newnham College, Cambridge.
1871. *Hughes, George Pringle, J.P. Middleton Hall, Wooler, Northumberland.
1887. ‡Hughes, John Taylor. Thorleymoor, Ashley-road, Altrincham.
1870. *Hughes, Lewis. Fenwick-chambers, Liverpool.
1891. §§Hughes, Thomas, F.C.S. 31 Loudoun-square, Cardiff.
1876. *Hughes, Rev. Thomas Edward. Wallfield House, Reigate.
1868. §§HUGHES, T. M'K., M.A., F.R.S., F.G.S., Woodwardian Professor of Geology in the University of Cambridge.
1891. ‡Hughes, Rev. W. Hawker. Jesus College, Oxford.
1865. ‡Hughes, W. R., F.L.S., Treasurer of the Borough of Birmingham. Birmingham.
1867. §HULL, EDWARD, M.A., LL.D., F.R.S., F.G.S. 20 Arundel-gardens, Notting Hill, London, W.
*Hulse, Sir Edward, Bart., D.C.L. 47 Portland-place, London, W.; and Breamore House, Salisbury.
1887. *HUMMEL, Professor J. J. 152 Woolsley-road, Leeds.
1890. ‡Humphrey, Frank W. 63 Prince's-gate, London, S.W.
1884. *Humphreys, A. W. 50 Broadway, New York, U.S.A.
1878. ‡Humphreys, H. Castle-square, Carnarvon.
1880. ‡Humphreys, Noel A., F.S.S. Ravenhurst, Hook, Kingston-on-Thames.
1862. *HUMPHRY, Sir GEORGE MURRAY, M.D., F.R.S., Professor of Surgery in the University of Cambridge. Grove Lodge, Cambridge.
1877. *HUNT, ARTHUR ROOPE, M.A., F.G.S. Southwood, Torquay.
1891. *Hunt, Cecil Arthur. Southwood, Torquay.
1886. ‡Hunt, Charles. The Gas Works, Windsor-street, Birmingham.
1891. ‡Hunt, D. de Vere, M.D. Westbourne-crescent, Sophia-gardens, Cardiff.
1865. ‡*Hunt, J. P. Gospel Oak Works, Tipton.*
1864. ‡*Hunt, W. Folkestone.*
1875. *Hunt, William. Northcote, Westbury-on-Trym, Bristol.
1881. ‡Hunter, F. W. Newbottle, Fence Houses, Co. Durham.
1889. ‡Hunter, Mrs. F. W. Newbottle, Fence Houses, Co. Durham.
1881. ‡Hunter, Rev. John. University-gardens, Glasgow.
1884. *Hunter, Michael. Greystones, Sheffield.
1869. *Hunter, Rev. Robert. LL.D., F.G.S. Forest Retreat, Staples-road, Loughton, Essex.
1879. ‡HUNTINGTON, A. K., F.C.S., Professor of Metallurgy in King's College, London. King's College, London, W.C.
1885. ‡Huntly, The Most Hon. the Marquess of. Aboyne Castle, Aberdeenshire.
1863. ‡Huntsman, Benjamin. West Retford Hall, Retford.
1883. *HURST, CHARLES HERBERT, Ph.D. Royal College of Science, Dublin.
1869. ‡Hurst, George. Bedford.
1882. ‡*Hurst, Walter, B.Sc. West Lodge, Todmorden.*
1861. *Hurst, William John. Drumaness Mills, Ballynahinch, Lisburn, Ireland.

Year of Election.

1870. ‡Hurter, Dr. Ferdinand. Appleton, Widnes, near Warrington.
1887. ‡Husband, W. E. 56 Bury New-road, Manchester.
1882. ‡Hussey, Major E. R., R.E. 24 Waterloo-place, Southampton.
1894. *Hutchinson, A. Pembroke College, Cambridge.
1876. ‡*Hutchinson, John. 22 Hamilton Park-terrace, Glasgow.*
Hutton, Crompton. Harescombe Grange, Stroud, Gloucestershire.
1864. *Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, London, N.W.
1857. ‡*Hutton, Henry D. 17 Palmerston-road, Dublin.*
1887. *Hutton, J. Arthur. The Meadows, Alderley Edge.
1861. *HUTTON, T. MAXWELL. Summerhill, Dublin.
Hyde, Edward. Dukinfield, near Manchester.
1883. ‡Hyde, George H. 23 Arbour-street, Southport.
1871. *Hyett, Francis A. Painswick House, Stroud, Gloucestershire.

1882. *I'Anson, James, F.G.S. Fairfield House, Darlington.
1883. ‡Idris, T. H. W. 58 Lady Margaret-road, London, N.W.
Ihne, William, Ph.D. Heidelberg.
1884. *Iles, George. 5 Brunswick-street, Montreal, Canada.
1885. ‡im-Thurn, Everard F., C.M.G., M.A. British Guiana.
1888. *Ince, Surgeon-Lieut.-Col. John, M.D. Montague House, Swanley, Kent.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1893.§§Ingle, Herbert. Pool, Leeds.
1876. ‡Inglis, John, jun. Prince's-terrace, Dowanhill, Glasgow.
1891. ‡Ingram, Lieut.-Colonel C. W. Bradford-place, Penarth.
1852. ‡INGRAM, J. K., LL.D., M.R.I.A., Senior Lecturer in the University of Dublin. 2 Wellington-road, Dublin.
1885. ‡Ingram, William, M.A. Gamrie, Banff.
1886. ‡Innes, John. The Limes, Alcester-road, Moseley, Birmingham.
1892. ‡Ireland, D. W. 10 South Gray-street, Edinburgh.
1892. ‡Irvine, James. Devonshire-road, Birkenhead.
1892. ‡Irvine, Robert, F.R.S.E. Royston, Granton, Edinburgh.
1882. §IRVING, Rev. A., B.A., D.Sc., F.G.S. Hockerill, Bishop Stortford, Herts.
1888. *Isaac, J. F. V., B.A. 114 Marine-parade, Brighton.
1883. ‡Isherwood, James. 18 York-road, Birkdale, Southport.
1881. ‡Ishiguro, Isoji. Care of the Japanese Legation, 9 Cavendish-square, London, W.
1891. *Ismay, Thomas H. 10 Water-street, Liverpool.
1886. ‡Izod, William. Church-road, Edgbaston, Birmingham.

1859. ‡Jack, John, M.A. Belhelvie-by-Whitecairns, Aberdeenshire.
1884. ‡Jack, Peter. People's Bank, Halifax, Nova Scotia, Canada.
1876. *Jack, William, LL.D., Professor of Mathematics in the University of Glasgow. 10 The College, Glasgow.
1883. *JACKSON, Professor A. H., B.Sc., F.C.S. 358 Collins-street, Melbourne, Australia.
1879. ‡Jackson, Arthur, F.R.C.S. Wilkinson-street, Sheffield.
1883. ‡Jackson, Frank. 11 Park-crescent, Southport.
1883. *Jackson, F. J. 1 Morley-road, Southport.
1883. ‡Jackson, Mrs. F. J. 1 Morley-road, Southport.
1874. *Jackson, Frederick Arthur. Belmont, Lyme Regis, Dorset.
1887. *Jackson, George. 53 Elizabeth-street, Cheetham, Manchester.
1885. ‡Jackson, Henry. 19 Golden-square, Aberdeen.
1866. ‡Jackson, H. W., F.R.A.S. 67 Upgate, Louth, Lincolnshire.

Year of Election.

1869. §Jackson, Moses, J.P. Lansdowne House, Tonbridge.
1887. §Jacobson, Nathaniel. Olive Mount, Cheetham Hill-road, Manchester.
1874. *Jaffe, John. 38 Promenade des Anglais, Nice, France.
1865. *Jaffray, Sir John, Bart. Park-grove, Edgbaston, Birmingham.
1891. ‡James, Arthur P. Grove House, Park-grove, Cardiff.
1891. *James, Charles Henry. 8 Courtland-terrace, Merthyr Tydfil.
1891. *James, Charles Russell. 6 New-court, Lincoln's Inn, London, W.C.
1872. ‡*James, Christopher. 8 Laurence Pountney-hill, London, E.C.*
1860. ‡James, Edward H. Woodside, Plymouth.
1886. ‡James, Frank. Portland House, Aldridge, near Walsall.
1891. ‡James, Ivor. University College, Cardiff.
1891. ‡James, John. 24 The Parade, Cardiff.
1891. ‡James, John Herbert. Howard House, Arundel-street, Strand, London, W.C.
1891. ‡James, J. R., L.R.C.P. 158 Cowbridge-road, Canton, Cardiff.
1858. ‡James, William C. Woodside, Plymouth.
1884. ‡Jameson, W. C. 48 Baker-street, Portman-square, London, W.
1881. ‡Jamieson, Andrew, Principal of the College of Science and Arts, Glasgow.
1887. §§Jamieson, G. Auldjo. 37 Drumsheugh-gardens, Edinburgh.
1885. ‡Jamieson, Patrick. Peterhead, N.B.
1885. ‡Jamieson, Thomas. 173 Union-street, Aberdeen.
1859. *Jamieson, Thomas F., LL.D., F.G.S. Ellon, Aberdeenshire.
1889. *JAPP, F. R., M.A., LL.D., F.R.S., F.C.S., Professor of Chemistry in the University of Aberdeen.
1870. ‡Jarrold, John James. London-street, Norwich.
1891. ‡*Jasper, Henry. Holmedale, New Park-road, Clapham Park, London, S.W.*
1891. ‡Jefferies, Henry. Plas Newydd, Park-road, Penarth.
1855. *Jeffray, John. 9 Winton-drive, Kelvinside, Glasgow.
1867. ‡Jeffreys, Howel, M.A. 61 Bedford-gardens, Kensington, London, W.
1885. ‡Jeffreys, Dr. Richard Parker. Eastwood House, Chesterfield.
1887. §JEFFS, OSMUND W. 92 Westbourne-street, Liverpool.
1864. ‡Jelly, Dr. W. Aveleanas, 11, Valencia, Spain.
1891. ‡Jenkins, Henry C., Assoc.M.Inst.C.E., F.C.S. 17 St. Julian's-road, Kilburn, London, N.W.
1873. §Jenkins, Major-General J. J. 16 St. James's-square, London, S.W.
1880. *JENKINS, Sir JOHN JONES. The Grange, Swansea.
1852. ‡Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1893. §Jennings, G. E. Ash Leigh-road, Leicester.
1878. ‡Jephson, Henry L. Chief Secretary's Office, The Castle, Dublin.
Jessop, William, jun. Overton Hall, Ashover, Chesterfield.
1889. ‡Jevons, F. B., M.A. The Castle, Durham.
1884. ‡Jewell, Lieutenant Theo. F. Torpedo Station, Newport, Rhode Island, U.S.A.
1891. ‡John, E. Cowbridge, Cardiff.
1884. ‡Johns, Thomas W. Yarmouth, Nova Scotia, Canada.
1884. §JOHNSON, ALEXANDER, M.A., LL.D., Professor of Mathematics in McGill University, Montreal. 5 Prince of Wales-terrace, Montreal, Canada.
1883. ‡Johnson, Miss Alice. Llandaff House, Cambridge.
1883. ‡Johnson, Ben. Micklegate, York.
1871. *Johnson, David, F.C.S., F.G.S. 11 Thurlow-terrace, Larkhall Rise, Clapham, London, S.W.

Year of Election.

1883. ‡Johnson, Edmund Litler. 73 Albert-road, Southport.
1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.
1888. ‡Johnson, J. G. Southwood Court, Highgate, London, N.
1875. ‡Johnson, James Henry, F.G.S. 73 Albert-road, Southport.
1872. ‡Johnson, J. T. 27 Dale-street, Manchester.
1870. ‡Johnson, Richard C., F.R.A.S. 46 Jermyn-street, Liverpool.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
1881. ‡Johnson, Sir Samuel George. Municipal Offices, Nottingham.
1890. *Johnson, Thomas, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.
1887. ‡Johnson, W. H. Woodleigh, Altrincham, Cheshire.
1883. ‡Johnson, W. H. F. Llandaff House, Cambridge.
1883. ‡Johnson, William. Harewood, Roe-lane, Southport.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham, Cheshire.
1883. ‡Johnston, H. H. Tudor House, Champion Hill, London, S.E.
1859. ‡Johnston, James. Newmill, Elgin, N.B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.W.
1884. ‡Johnston, John L. 27 St. Peter-street, Montreal, Canada.
1883 ‡Johnston, Thomas. Broomsleigh, Seal, Sevenoaks.
1884. ‡Johnston, Walter R. Fort Qu'Appelle, N.W. Territory, Canada.
1884. *Johnston, W. H. County Offices, Preston, Lancashire.
1885. ‡JOHNSTON-LAVIS, H. J., M.D., F.G.S. Beaulieu, Alpes Maritimes, France.
1886. ‡Johnstone, G. H. Northampton-street, Birmingham.
1864. *Johnstone, James. Alva House, Alva, by Stirling, N.B.
1864. ‡Jolly, Thomas. Park View-villas, Bath.
1871. ‡JOLLY, WILLIAM, F.R.S.E., F.G.S., H.M. Inspector of Schools. St. Andrew's-road, Pollokshields, Glasgow.
1888. ‡Jolly, W. C. Home Lea, Lansdowne, Bath.
1888. ‡JOLY, JOHN, M.A., D.Sc., F.R.S. 39 Waterloo-road, Dublin.
1881. ‡Jones, Alfred Orlando, M.D. Cardigan Villa, Harrogate.
1849. ‡Jones, Baynham. Walmer House, Cheltenham.
1887. ‡Jones, D. E., B.Sc., H.M. Inspector of Schools. 7 Marine-terrace, Aberystwith.
1891. ‡Jones, D. Edgar, M.D. Spring Bank, Queen-street, Cardiff.
1890. §Jones, Rev. Edward, F.G.S. Fairfax-road, Prestwich, Lancashire.
1891. ‡Jones, Dr. Evan. Aberdare.
1887. ‡Jones, Francis, F.R.S.E., F.C.S. Beaufort House, Alexandra Park, Manchester.
1891. *JONES, Rev. G. HARTWELL, M.A. Nutfield Rectory, Redhill, Surrey.
1883. *Jones, George Oliver, M.A. 5 Cook-street, Liverpool.
1895. §Jones, Harry. Engineer's Office, Great Eastern Railway, Ipswich.
1884. ‡Jones, Rev. Harry, M.A. 8 York-gate, Regent's Park, London, N.W.
1877. ‡Jones, Henry C., F.C.S. Royal College of Science, South Kensington, London, S.W.
1893. †Jones, Professor J. E., B.Sc.
1881. *JONES, J. VIRIAMU, M.A., B.Sc., F.R.S., Principal of the University College of South Wales and Monmouthshire, Cardiff.
1873. ‡Jones, Theodore B. 1 Finsbury-circus, London, E.C.
1880. ‡Jones, Thomas. 15 Gower-street, Swansea.
1860. ‡JONES, THOMAS RUPERT, F.R.S., F.G.S. 17 Parson's-Green, Fulham, London, S.W.
1883. ‡Jones, William. Elsinore, Birkdale, Southport.
1891. ‡Jones, William Lester. 22 Newport-road, Cardiff.

Year of
Election.
1875. *Jose, J. E. 49 Whitechapel, Liverpool.
1884. ‡Joseph, J. H. 738 Dorchester-street, Montreal, Canada.
1891. ‡Jotham, F. H. Penarth.
1891. ‡Jotham, T. W. Penylan, Cardiff.
1875. *Joule, Benjamin St. John B., J.P. Rothesay, N.B.
1879. ‡Jowitt, A. Scotia Works, Sheffield.
1890. ‡Jowitt, Benson R. Elmhurst, Newton-road, Leeds.
1872. ‡Joy, Algernon. Junior United Service Club, St. James's, London, S.W.
1848. *Joy, Rev. Charles Ashfield. West Hanney, Wantage, Berkshire.
1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.
1886. ‡Joyce, The Hon. Mrs. St. John's Croft, Winchester.
1891. ‡Joynes, John J. Great Western Colliery, near Coleford, Gloucestershire.
1848. *Jubb, Abraham. Halifax.
1870. ‡JUDD, JOHN WESLEY, C.B., F.R.S., F.G.S., Professor of Geology in the Royal College of Science, London. 16 Cumberland-road, Kew.
1883. ‡Justice, Philip M. 14 Southampton-buildings, Chancery-lane, London, W.C.

1868. *Kaines, Joseph, M.A., D.Sc. 8 Osborne-road, Stroud Green-road, London, N.
1888. ‡Kapp, Gisbert, M.Inst.C.E., M.Inst.E.E. 3 Lindenallee, Westend, Berlin.
1887. ‡Kay, Miss. Hamerlaund, Broughton Park, Manchester.
1859. ‡Kay, David, F.R.G.S. 19 Upper Phillimore-place, Kensington, London, W.
1883. ‡*Kearne, John H. Westcliffe-road Birkdale, Southport.*
1884. ‡Keefer, Samuel. Brockville, Ontario, Canada.
1875. ‡Keeling, George William. Tuthill, Lydney.
1886. ‡Keen, Arthur, J.P. Sandyford, Augustus-road, Birmingham.
1894. §Keene, Captain C. T. P., F.L.S., F.Z.S., F.S.S. 11 Queen's-gate, London, S.W
1894. §Keightley, Rev. G. W. Great Stambridge Rectory, Rochford, Essex.
1892. ‡Keiller, Alexander, M.D., LL.D., F.R.S.E. 54 Northumberland-street, Edinburgh.
1887. ‡Kellas-Johnstone, J. F. 35 Crescent, Salford.
1884. ‡Kellogg, J. H., M.D. Battle Creek, Michigan, U.S.A.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1885. §Keltie, J. Scott, Assist.Sec.R.G.S., F.S.S. 1 Savile-row, London, W.
1847. *KELVIN, The Right Hon. Lord, M.A., LL.D., D.C.L., Pres.R.S., F.R.S.E., F.R.A.S., Professor of Natural Philosophy in the University of Glasgow. The University, Glasgow.
1877. *Kelvin, Lady. The University, Glasgow.
1887. ‡Kemp, Harry. 254 Stretford-road, Manchester.
1884. ‡Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.
1890. §Kempson, Augustus. Kildare, Arundel-road, Eastbourne.
1891. §KENDALL, PERCY F., F.G.S. Yorkshire College, Leeds.
1875. ‡KENNEDY, ALEXANDER B. W., F.R.S., M.Inst.C.E., Emeritus Professor of Engineering in University College, London. 2 Gloucester-place, Portman-square, London, W.
1884. ‡Kennedy, George L., M.A., F.G.S., Professor of Chemistry and Geology in King's College, Windsor, Nova Scotia, Canada.
1876. ‡Kennedy, Hugh. 20 Mirkland-street, Glasgow.
1884. ‡Kennedy, John. 113 University-street, Montreal, Canada.

Year of
Election.

1884. ‡Kennedy, William. Hamilton, Ontario, Canada.
1886. ‡Kenrick, George Hamilton. Whetstone, Somerset-road, Edgbaston, Birmingham.
1893. §Kent, A. F. Stanley, F.G.S. St. Thomas's Hospital, London, S.E.
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1886. §KENWARD, JAMES, F.S.A., Assoc.M.Inst.C.E. 280 Hagley-road, Birmingham.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1876. ‡Ker, William. 1 Windsor-terrace West, Glasgow.
1881. ‡Kermode, Philip M. C. Ramsay, Isle of Man.
1892. §Kerr, J. Graham. Christ's College, Cambridge.
1884. ‡Kerr, James, M.D. Winnipeg, Canada.
1887. ‡Kerr, James. Dunkenhalgh, Accrington.
1883. ‡KERR, REV. JOHN, LL.D., F.R.S. Free Church Training College, Glasgow.
1889. ‡Kerry, W. H. R. Wheatlands, Windermere.
1887. ‡Kershaw, James. Holly House, Bury New-road, Manchester.
1869. *Kesselmeyer, Charles A. Rose Villa, Vale-road, Bowdon, Cheshire.
1869. *Kesselmeyer, William Johannes. Rose Villa, Vale-road, Bowdon, Cheshire.
1883. *Keynes, J. N., M.A., D.Sc., F.S.S. 6 Harvey-road, Cambridge.
1876. ‡Kidston, J. B. 50 West Regent-street, Glasgow.
1886. §KIDSTON, ROBERT, F.R.S.E., F.G.S. 24 Victoria-place, Stirling.
1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.
1890. ‡Kimmins, C. W., M.A., D.Sc. Downing College, Cambridge.
1878. ‡Kinahan, Sir Edward Hudson, Bart. 11 Merrion-square North, Dublin.
1860. ‡KINAHAN, G. HENRY, M.R.I.A. Geological Survey of Ireland, 14 Hume-street, Dublin.
1875. *KINCH, EDWARD, F.C.S. Royal Agricultural College, Cirencester.
1888. ‡King, Austin J. Winsley Hill, Limpley Stoke, Bath.
1888. *King, E. Powell. Wainsford, Lymington, Hants.
1883. *King, Francis. Alabama, Penrith.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1883. *King, John Godwin. Wainsford, Lymington, Hants.
1870. ‡King, John Thomson. 4 Clayton-square, Liverpool.
King, Joseph. Welford House, Greenhill, Hampstead, London, N.W.
1883. *King, Joseph, jun. Lower Birtley, Witley, Godalming.
1860. *King, Mervyn Kersteman. 3 Clifton-park, Clifton, Bristol.
1875. *King, Percy L. 2 Worcester-avenue, Clifton, Bristol.
1870. ‡King, William. 5 Beach Lawn, Waterloo, Liverpool.
1889. §King, Sir William. Stratford Lodge, Southsea.
1869. ‡Kingdon, K. Taddiford, Exeter.
1875. §KINGZETT, CHARLES T., F.C.S. Elmstead Knoll, Chislehurst, Kent.
1867. ‡Kinloch, Colonel. Kirriemuir, Logie, Scotland.
1892. ‡Kinnear, The Hon. Lord, F.R.S.E. Blair Castle, Culross, N.B.
1870. ‡Kinsman, William R. Branch Bank of England, Liverpool.
1875. ‡*Kirsop, John. 6 Queen's-crescent, Glasgow.*
1883. ‡*Kirsop, Mrs. 6 Queen's-crescent, Glasgow.*
1870. ‡Kitchener, Frank E. Newcastle, Staffordshire.
1890. *KITSON, Sir JAMES, Bart., M.P. Gledhow Hall, Leeds.
1886. ‡Klein, Rev. L. Martial. University College, Dublin.
1869. ‡Knapman, Edward. The Vineyard, Castle-street, Exeter.
1886. ‡Knight, J. M., F.G.S. Bushwood, Wanstead, Essex.

Year of
Election.

1888. ‡Knott, Professor Cargill G., D.Sc., F.R.S.E. 42 Upper Gray-street, Edinburgh.
1887. *Knott, Herbert. Wharf Street Mills, Ashton-under-Lyne.
1887. *Knott, John F. Staveleigh, Stalybridge, Cheshire.
1887. ‡Knott, Mrs. Staveleigh, Stalybridge, Cheshire.
1873. *Knowles, George. Moorhead, Shipley, Yorkshire.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1883. ‡Knowlys, Rev. C. Hesketh. The Rectory, Roe-lane, Southport.
1883. ‡Knowlys, Mrs. C. Hesketh. The Rectory, Roe-lane, Southport.
1876. ‡Knox, David N., M.A., M.B. 24 Elmbank-crescent, Glasgow.
*Knox, George James. 27 Portland-terrace, Regent's Park, London, N.W.
1875. *Knubley, Rev. E. P., M.A. Staveley Rectory, Leeds.
1883. ‡Knubley, Mrs. Staveley Rectory, Leeds.
1892. ‡Kohn, Dr. Charles A. University College, Liverpool.
1890. *Krauss, John Samuel, B.A. Wilmslow, Cheshire.
1888. *Kunz, G. F. Care of Messrs. Tiffany & Co., 11 Union-square, New York City, U.S.A.
1881. ‡Kurobe, Hiroo. Legation of Japan, 9 Cavendish-square, London, W.
1870. ‡Kynaston, Josiah W., F.C.S. Kensington, Liverpool.
1865. ‡*Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.*

1858. ‡Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1884. ‡Laflamme, Rev. Professor J. C. K. Laval University, Quebec, Canada.
1885. *Laing, J. Gerard. 111 Church-street, Chelsea, S.W.
1870. §Laird, John. Grosvenor-road, Claughton, Birkenhead.
1877. ‡Lake, W. C., M.D., F.R.G.S. Teignmouth.
1859. ‡Lalor, John Joseph, M.R.I.A. City Hall, Cork Hill, Dublin.
1889. *Lamb, Edmund, M.A. Old Lodge, Salisbury.
1887. ‡Lamb, Horace, M.A., F.R.S., Professor of Pure Mathematics in the Owens College, Manchester. Burton-road, Didsbury, Manchester.
1887. ‡Lamb, James. Kenwood, Bowdon, Cheshire.
1883. ‡Lamb, W. J. 11 Gloucester-road, Birkdale, Southport.
1883. ‡Lambert, Rev. Brooke, LL.B. The Vicarage, Greenwich, S.E.
1893. ‡Lambert, J. W., J.P. Lenton Firs, Nottingham.
1884. ‡Lamborn, Robert H. Montreal, Canada.
1893. §Lamplugh, G. W., F.G.S. Geological Survey Office, Jermyn-street, London, S.W.
1890. ‡Lamport, Edward Parke. Greenfield Well, Lancaster.
1884. ‡Lancaster, Alfred. Fern Bank, Burnley, Lancashire.
1871. ‡Lancaster, Edward. Karesforth Hall, Barnsley, Yorkshire.
1886. ‡Lancaster, W. J., F.G.S. Colmore-row, Birmingham.
1877. ‡Landon, Frederic George, M.A., F.R.A.S. 59 Tresillian-road, St. John's, London, S.E.
1883. ‡Lang, Rev. Gavin. Inverness.
1859. ‡Lang, Rev. John Marshall, D.D. Barony, Glasgow.
1886. *Langley, J. N., M.A., F.R.S. Trinity College, Cambridge.
1870. ‡Langton, Charles. Barkhill, Aigburth, Liverpool.
1865. ‡Lankester, E. Ray, M.A., LL.D., F.R.S., Linacre Professor of Human and Comparative Anatomy in the University of Oxford. 2 Bradmore-road, Oxford.
1880. *Lansdell, Rev. Henry, D.D., F.R.A.S., F.R.G.S. Morden College, Blackheath, London, S.E.

Year of Election.

1884. §Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.
1878. ‡Lapper, E., M.D. 61 Harcourt-street, Dublin.
1885. ‡LAPWORTH, CHARLES, LL.D., F.R.S., F.G.S., Professor of Geology and Physiography in the Mason Science College, Birmingham. 13 Duchess-road, Edgbaston, Birmingham.
1887. ‡Larmor, Alexander. Clare College, Cambridge.
1881. ‡LARMOR, JOSEPH, M.A., D.Sc., F.R.S. St. John's College, Cambridge.
1883. §Lascelles, B. P., M.A. The Moat, Harrow.
1870. *LATHAM, BALDWIN, M.Inst.C.E., F.G.S. 7 Westminster-chambers, Westminster, S.W.
1870. ‡Laughton, John Knox, M.A., F.R.G.S. Catesby House, Manor-road, Barnet, Herts.
1891. ‡Laurie, A. P. 49 Beaumont-square, London, E.
1888. ‡Laurie, Colonel R. P., C.B. 79 Farringdon-street, London, E.C.
1892. §Laurie, Malcolm, B.A., B.Sc., F.L.S. King's College, Cambridge.
1883. ‡Laurie, Major-General. Oakfield, Nova Scotia.
1870. *Law, Channell. Ilsham Dene, Torquay.
1878. ‡Law, Henry, M.Inst.C.E. 9 Victoria-chambers, London, S.W.
1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.
1884. §Law, Robert, F.G.S. Fennyroyd Hall, Hipperholme, near Halifax, Yorkshire.
1870. ‡Lawrence, Edward. Aigburth, Liverpool.
1881. ‡Lawrence, Rev. F., B.A. The Vicarage, Westow, York.
1889. §Laws, W. G., M.Inst.C.E. 5 Winchester-terrace, Newcastle-upon-Tyne.
1875. ‡Lawson, George, Ph.D., LL.D., Professor of Chemistry and Botany. Halifax, Nova Scotia.
1885. ‡Lawson, James. 8 Church-street, Huntly, N.B.
1868. *Lawson, M. Alexander, M.A., F.L.S. Ootâcamund, Bombay.
1853. ‡*Lawton, William. 5 Victoria-terrace, Derringham, Hull.*
1888. §Layard, Miss Nina F. 2 Park-place, Fonnereau-road, Ipswich.
1856. ‡Lea, Henry. 38 Bennett's-hill, Birmingham.
1883. *Leach, Charles Catterall. Seghill, Northumberland.
1875. ‡Leach, Colonel Sir G., K.C.B., R.E. 6 Wetherby-gardens, London, S.W.
1870. *Leaf, Charles John, F.L.S., F.G.S., F.S.A. 6 Sussex-place, Regent's Park, London, N.W.
1894. *Leahy, A. H., M.A., Professor of Mathematics in Firth College, Sheffield.
1884. *Leahy, John White, J.P. South Hill, Killarney, Ireland.
1884. ‡Learmont, Joseph B. 120 Mackay-street, Montreal, Canada.
1847. *LEATHAM, EDWARD ALDAM. 46 Eaton-square, London, S.W.
1863. ‡Leavers, J. W. The Park, Nottingham.
1884. *Leavitt, Erasmus Darwin. 2 Central-square, Cambridgeport, Massachusetts, U.S.A.
1872. ‡LEBOUR, G. A., M.A., F.G.S., Professor of Geology in the College of Physical Science, Newcastle-on-Tyne.
1884. ‡Leckie, R. G. Springhill, Cumberland County, Nova Scotia.
1895. §Ledger, Rev. Edmund. Barham Rectory, Ipswich.
1861. ‡Lee, Henry. Sedgeley Park, Manchester.
1891. §Lee, Mark. The Cedars, Llandaff-road, Cardiff.
1884. *Leech, Sir Bosdin T. Oak Mount, Timperley, Cheshire.
1887. ‡Leech, D. J., M.D., Professor of Materia Medica in the Owens College, Manchester. Elm House, Whalley Range, Manchester.
1892. *LEES, CHARLES H., M.Sc. 6 Heald-road, Rusholme, Manchester.
1886. *Lees, Lawrence W. Claregate, Tettenhall, Wolverhampton.

Year of Election.

1882. ‡Lees, R. W. Moira-place, Southampton.
1859. ‡Lees, William, M.A. 12 Morningside-place, Edinburgh.
1883. *Leese, Miss H. K. 3 Lord-street West, Southport.
*Leese, Joseph. 3 Lord-street West, Southport.
1889. *Leeson, John Rudd, M.D., C.M., F.L.S., F.G.S. Clifden House, Twickenham, Middlesex.
1881. ‡Le Feuvre, J. E. Southampton.
1872. ‡Lefevre, The Right Hon. G. Shaw, F.R.G.S. 18 Bryanston-square, London, W.
1869. ‡Le Grice, A. J. Trereife, Penzance.
1892. §§Lehfeldt, Robert A. Firth College, Sheffield.
1868. ‡Leicester, The Right Hon. the Earl of, K.G. Holkham, Norfolk.
1856. ‡Leigh, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.
1890. ‡Leigh, Marshall. 22 Goldsmid-road, Brighton.
1891. ‡Leigh, W. W. Treharris, R.S.O., Glamorganshire.
1867. ‡Leishman, James. Gateacre Hall, Liverpool.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie, N.B.
1882. §Lemon, James, M.Inst.C.E., F.G.S. Lansdowne House, Southampton.
1867. ‡Leng, Sir John, M.P. 'Advertiser' Office, Dundee.
1878. ‡Lennon, Rev. Francis. The College, Maynooth, Ireland.
1887. *Leon, John T. 38 Portland-place, London, W.
1874. ‡Lepper, Charles W. Laurel Lodge, Belfast.
1884. ‡Lesage, Louis. City Hall, Montreal, Canada.
1890. *Lester, Joseph Henry. 51 Arcade-chambers, St. Mary's Gate, Manchester.
1883. §§Lester, Thomas. Fir Bank, Penrith.
1880. ‡Letcher, R. J. Lansdowne-terrace, Walters-road, Swansea.
1894. §§Leudesdorf, Charles. Pembroke College, Oxford.
1887. *Levinstein, Ivan. Manchester.
1890. ‡Levy, J. H. Florence, 12 Abbeville-road South, Clapham Park, London, S.W.
1893. *Lewes, Vivian B., F.C.S., Professor of Chemistry in the Royal Naval College, Greenwich, S.E.
1879. ‡Lewin, Colonel, F.R.G.S. Garden Corner House, Chelsea Embankment, London, S.W.
1870. ‡Lewis, Alfred Lionel. 54 Highbury-hill, London, N.
1891. ‡Lewis, D., J.P. 44 Park-place, Cardiff.
1891. §Lewis, D. Morgan, M.A. University College, Aberystwith.
1891. ‡Lewis, W. Lyncombe Villa, Cowbridge-road, Cardiff.
1891. ‡Lewis, W. 22 Duke-street, Cardiff.
1891. ‡Lewis, W. Henry. Bryn Rhos, Llanishen, Cardiff.
1884. *Lewis, Sir W. T. The Mardy, Aberdare.
1860. ‡Liddell, The Very Rev. H. G., D.D. Ascot, Berkshire.
1887. ‡Liebermann, L. 54 Portland-street, Manchester.
1876. ‡Lietke, J. O. 30 Gordon-street, Glasgow.
1887. *Lightbown, Henry. Weaste Hall, Pendleton, Manchester.
1862. ‡Lilford, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*Limerick, The Right Rev. Charles Graves, Lord Bishop of, D.D., F.R.S., M.R.I.A. The Palace, Henry-street, Limerick.
1887. ‡Limpach, Dr. Crumpsall Vale Chemical Works, Manchester.
1878. ‡Lincolne, William. Ely, Cambridgeshire.
1881. *Lindley, William, M.Inst.C.E., F.G.S. 74 Shooters Hill-road, Blackheath, London, S.E.
1871. ‡Lindsay, Rev. T. M., M.A., D.D. Free Church College, Glasgow.
1883. ‡*Lipscomb, Mrs. Lancelot C. d'A. 95 Elgin-crescent, London, W.*

Year of Election.

1883. ‡Lisle, H. Claud. Nantwich.
1895.§§Lister, Sir Joseph, Bart., D.C.L., For.Sec.R.S. (President Elect), 12 Park-crescent, Portland-place, W.
1882. *Lister, Rev. Henry, M.A. Hawridge Rectory, Berkhampstead.
1888. ‡Lister, J. J. Leytonstone, Essex, E.
1861. *Liveing, G. D., M.A., F.R.S., F.C.S., Professor of Chemistry in the University of Cambridge. Newnham, Cambridge.
1876. *Liversidge, Archibald, M.A., F.R.S., F.C.S., F.G.S., F.R.G.S., Professor of Chemistry in the University of Sydney, N.S.W. Care of Messrs. Kegan Paul, Trench, Trübner & Co., Charing Cross-road, London, W.C.
1864.§§Livesay, J. G. Cromartie House, Ventnor, Isle of Wight.
1880. ‡Llewelyn, Sir John T. D., Bart. Penllegare, Swansea.
Lloyd, Rev. A. R. Hengold, near Oswestry.
1889. ‡Lloyd, Rev. Canon. The Vicarage, Rye Hill, Newcastle-upon-Tyne.
1842. Lloyd, Edward. King-street, Manchester.
1865. ‡Lloyd, G. B., J.P. Edgbaston-grove, Birmingham.
1865. ‡Lloyd, John. Queen's College, Birmingham.
1886. ‡Lloyd, John Henry. Ferndale, Carpenter-road, Edgbaston, Birmingham.
1891. *Lloyd, R. J., M.A., D.Litt. 4 Halkyn-avenue, Sefton Park, Liverpool.
1886. ‡Lloyd, Samuel. Farm, Sparkbrook, Birmingham.
1865. *Lloyd, Wilson, M.P., F.R.G.S. Myvod House, Wednesbury.
1854. *Lobley, James Logan, F.G.S. City of London College, Moorgate-street, E.C., 1 Carrington Street, W.
1892. §Loch, C. S., B.A. 15a Buckingham-street, London, W.C.
1867. *Locke, John. 231 Clarence-road, Kentish Town, London, N.W.
1892. ‡Lockhart, Robert Arthur. 10 Polwarth-terrace, Edinburgh.
1863. ‡Lockyer, J. Norman, C.B., F.R.S., F.R.A.S. Royal College of Science, South Kensington, London, S.W.
1886. *Lodge, Alfred, M.A., Professor of Pure Mathematics in the Royal Indian Civil Engineering College, Cooper's Hill, Staines.
1875. *Lodge, Oliver J., D.Sc., LL.D., F.R.S., Professor of Physics in University College, Liverpool. 2 Grove-park, Liverpool.
1894. *Lodge, Oliver W. F. 2 Grove-park, Liverpool.
1889. ‡Logan, William. Langley Park, Durham.
1876. ‡Long, H. A. Charlotte-street, Glasgow.
1883. *Long, William. Thelwall Heys, near Warrington.
1883. ‡Long, Mrs. Thelwall Heys, near Warrington.
1883. ‡Long, Miss. Thelwall Heys, near Warrington.
1866. ‡Longdon, Frederick. Osmaston-road, Derby.
1883. ‡Longe, Francis D. Coddenham Lodge, Cheltenham.
1883. ‡Longmaid, William Henry. 4 Rawlinson-road, Southport.
1875. *Longstaff, George Blundell, M.A., M.D., F.C.S., F.S.S. Highlands, Putney Heath, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon, Surrey.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, Surrey.
1883. *Longton, E. J., M.D. The Priory, Southport.
1861. *Lord, Edward. Adamroyd, Todmorden.
1894.§§Lord, Edwin C. E., Ph.D. 247 Washington-street, Brooklyn, New York, U.S.A.
1889. ‡Lord, Riley. 75 Pilgrim-street, Newcastle-upon-Tyne.
1883. *Louis, D. A., F.C.S. 77 Shirland-gardens, London, W.
1887. *Love, A. E. H., M.A., F.R.S. St. John's College, Cambridge.

Year of Election.

1886. *Love, E. F. J., M.A. The University, Melbourne, Australia.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 11 Campden Hill-square, London, W.
1883. ‡Love, James Allen. 8 Eastbourne-road West, Southport.
1875. *Lovett, W. Jesse, F.I.C. 29 Park-crescent, Monkgate, York.
1892. §Lovibond, J. W. Salisbury, Wiltshire.
1889. ‡Low, Charles W. 84 Westbourne-terrace, London, W.
1867. *Low, James F. Monifieth, by Dundee.
1885. §Lowdell, Sydney Poole. Baldwin's Hill, East Grinstead, Sussex.
1891. §Lowdon, John. St. Hilda's, Barry, Cardiff.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1892. ‡Lowe, D. T. Heriot's Hospital, Edinburgh.
1861. *Lowe, Edward Joseph, F.R.S., F.R.A.S., F.L.S., F.G.S., F.R.M.S. Shirenewton Hall, near Chepstow.
1884. ‡*Lowe, F. J. Elm-court, Temple, London, E.C.*
1886. *Lowe, John Landor, M.Inst.C.E. The Birches, Burton-road, Derby.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
1894. §§Lowenthal, Miss Nellie. 60 New North-road, Huddersfield.
1881. ‡Lubbock, Arthur Rolfe. High Elms, Farnborough, R.S.O., Kent.
1853. *Lubbock, The Right Hon. Sir John, Bart., M.P., D.C.L., LL.D., F.R.S., F.L.S., F.G.S. High Elms, Farnborough, R.S.O., Kent.
1881. ‡Lubbock, John B. 14 Berkeley-street, London, W.
1870. ‡Lubbock, Montague, M.D. 19 Grosvenor-street, London, W.
1889. ‡Lucas, John. 1 Carlton-terrace, Low Fell, Gateshead.
1878. ‡Lucas, Joseph. Tooting Graveney, London, S.W.
1889. ‡Luckley, George. The Grove, Jesmond, Newcastle-upon-Tyne.
1891. *Lucovich, Count A. The Rise, Llandaff.
1875. ‡Lucy, W. C., F.G.S. The Winstones, Brookthorpe, Gloucester.
1881. ‡Luden, C. M. 4 Bootham-terrace, York.
1866. *Lund, Charles. Ilkley, Yorkshire.
1873. ‡Lund, Joseph. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 32 Newport-road, Cardiff.
1892. ‡Lunn, Robert. Geological Survey Office, Sheriff Court House, Edinburgh.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1883. *Lupton, Arnold, M.Inst.C.E., F.G.S., Professor of Coal Mining in Yorkshire College. 6 De Grey-road, Leeds.
1874. *Lupton, Sydney, M.A. Grove Cottage, Roundhay, near Leeds.
1864. *Lutley, John. Brockhampton Park, Worcester.
1871. ‡Lyell, Sir Leonard, Bart., M.P., F.G.S. 48 Eaton-place, London, S.W.
1884. ‡Lyman, A. Clarence. 84 Victoria-street, Montreal, Canada.
1884. ‡Lyman, H. H. 74 McTavish-street, Montreal, Canada.
1874. ‡Lynam, James. Ballinasloe, Ireland.
1885. §Lyon, Alexander, jun. 52 Carden-place, Aberdeen.
1862. *Lyte, F. Maxwell, F.C.S. 60 Finborough-road, London, S.W.

1852. ‡*McAdam, Robert.* 18 *College-square East, Belfast.*
1854. *Macadam, Stevenson, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh; and Brighton House, Portobello, by Edinburgh.
1876. *Macadam, William Ivison., F.R.S.E., F.I.C., F.C.S. Surgeons' Hall, Edinburgh.
1868. ‡Macalister, Alexander, M.A., M.D., F.R.S., Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.

Year of Election.

1878. ‡MacAlister, Donald, M.A., M.D., B.Sc. St. John's College, Cambridge.
1879. §MacAndrew, James J., F.L.S. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1883. §MacAndrew, William. Westwood House, near Colchester.
1866. *M'Arthur, Alexander, F.R.G.S. 79 Holland Park, London, W.
1884. ‡Macarthur, D. Winnipeg, Canada.
1834. Macaulay, James, A.M., M.D. 25 Carlton-vale, London, N.W.
1840. ***MacBrayne, Robert.** *65 West Regent-street, Glasgow.*
1884. ‡McCabe, T., Chief Examiner of Patents. Patent Office, Ottawa, Canada.
1886. ‡MacCarthy, Rev. E. F. M., M.A. 93 Hagley-road, Birmingham.
1887. *McCarthy, James. Bangkok, Siam.
1884. *McCarthy, J. J., M.D. 83 Wellington-road, Dublin.
1884. ‡McCausland, Orr. Belfast.
1891. *McClean, Frank, M.A., F.R.S., F.S.S. Rusthall House, Tunbridge Wells.
1876. *M'Clelland, A. S. 4 Crown-gardens, Dowanhill, Glasgow.
1868. ‡M'Clintock, Admiral Sir Francis L., R.N., K.C.B., F.R.S., F.R.G.S. United Service Club, Pall Mall, London, S.W.
1878. *M'Comas, Henry. Homestead, Dundrum, Co. Dublin.
1892. *McCowan, John, M.A., D.Sc. University College, Dundee.
1892. ‡McCrae, George. 3 Dick-place, Edinburgh.
1883. ‡McCrossan, James. 92 Huskisson-street, Liverpool.
1886. ‡McDonald, John Allen. Hillsboro' House, Derby.
1884. ‡MacDonald, Kenneth. Town Hall, Inverness.
1884. *McDonald, W. C. 891 Sherbrooke-street, Montreal, Canada.
1884. ‡MacDonnell, Mrs. F. H. 1433 St. Catherine-street, Montreal, Canada.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1883. ‡MacDonnell, Rev. Canon J. C., D.D. Misterton Rectory, Lutterworth.
1878. ‡McDonnell, James. 32 Upper Fitzwilliam-street, Dublin.
1884. ‡Macdougall, Alan, M.Inst.C.E. 32 Adelaide-street East, Toronto, Canada.
1884. ‡McDougall, John. 35 St. François Xavier-street, Montreal, Canada.
1881. ‡Macfarlane, Alexander, D.Sc., F.R.S.E., Professor of Physics in the University of Texas. Austin, Texas, U.S.A.
1871. ‡M'Farlane, Donald. The College Laboratory, Glasgow.
1885. ‡Macfarlane, J. M., D.Sc., F.R.S.E., Professor of Biology in the University of Pennsylvania, Lansdowne, Delaware Co., Pennsylvania, U S.A.
1879. ‡Macfarlane, Walter, jun. 12 Lynedoch-crescent, Glasgow.
1884. ‡*Macfie, K. N., B.A., B.C.L. Winnipeg, Canada.*
1867. *M'Gavin, Robert. Ballumbie, Dundee.
1888. ‡MacGeorge, James. 67 Marloes-road, Kensington, London, W.
1884. ‡MacGillivray, James. 42 Cathcart-street, Montreal, Canada.
1884. ‡MacGoun, Archibald, jun., B.A., B.C.L. 19 Place d'Armes, Montreal, Canada.
1873. ‡McGowen, William Thomas. Oak-avenue, Oak Mount, Bradford, Yorkshire.
1885. ‡Macgregor, Alexander, M.D. 256 Union-street, Aberdeen.
1884. *MacGregor, James Gordon, M.A., D.Sc., F.R.S.E., Professor of Physics in Dalhousie College, Halifax, Nova Scotia, Canada.
1885. ‡M'Gregor-Robertson, J., M.A., M.B. 26 Buchanan-street, Hillhead, Glasgow.
1876. ‡M'Grigor, Alexander B., LL.D. 19 Woodside-terrace, Glasgow.

Year of Election.

1867. *M'INTOSH, W. C., M.D., LL.D., F.R.S., F.R.S.E., F.L.S., Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.
1884. ‡McIntyre, John, M.D. Odiham, Hants.
1883. ‡Mack, Isaac A. Trinity-road, Bootle.
1884. ‡Mackay, Alexander Howard, B.A., B.Sc. The Academy, Pictou, Nova Scotia, Canada.
1885. §§MACKAY, JOHN YULE, M.D. The University, Glasgow.
1873. ‡McKENDRICK, JOHN G., M.D., LL.D., F.R.S., F.R.S.E., Professor of Physiology in the University of Glasgow. 2 Florentine-gardens, Glasgow.
1883. ‡McKendrick, Mrs. 2 Florentine Gardens, Glasgow.
1880. **Mackenzie, Colin. Junior Athenæum Club, Piccadilly, London, W.*
1884. ‡McKenzie, Stephen, M.D. 26 Finsbury-circus, London, E.C.
1884. ‡McKenzie, Thomas, B.A. School of Science, Toronto, Canada.
1883. ‡Mackeson, Henry. Hythe, Kent.
1872. *Mackey, J. A. 175 Grange-road, London, S.E.
1867. ‡MACKIE, SAMUEL JOSEPH. 17 Howley-place, London, W.
1884. ‡McKilligan, John B. 387 Main-street, Winnipeg, Canada.
1887. ‡MACKINDER, H. J., M.A., F.R.G.S. Christ Church, Oxford.
1867. *Mackinlay, David. 6 Great Western-terrace, Hillhead, Glasgow.
1889. ‡McKinley, Rev. D. 33 Milton-street, West Hartlepool.
1891. ‡Mackintosh, A. C. Temple Chambers, Cardiff.
1850. ‡Macknight, Alexander. 20 Albany-street, Edinburgh.
1867. ‡*Mackson, H. G. 25 Cliff-road, Woodhouse, Leeds.*
1872. *McLACHLAN, ROBERT, F.R.S., F.L.S. West View, Clarendon-road, Lewisham, S.E.
1892. §§MACLAGAN, Sir DOUGLAS, M.D., LL.D., F.R.S.E., Professor of Medical Jurisprudence in the University of Edinburgh. 28 Heriot-row, Edinburgh.
1892. ‡Maclagan, Philip K. D. 14 Belgrave-place, Edinburgh.
1892. ‡Maclagan, R. Craig, M.D., F.R.S.E. 5 Coates-crescent Edinburgh.
1873. ‡McLandsborough, John, F.R.A.S., F.G.S. Manningham, Bradford, Yorkshire.
1885. *M'LAREN, The Hon. Lord, F.R.S.E., F.R.A.S. 46 Moray-place, Edinburgh.
1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.
1873. ‡MacLaren, Walter S. B. Newington House, Edinburgh.
1882. ‡Maclean, Inspector-General, C.B. 1 Rockstone-terrace, Southampton.
1892. *Maclean, Magnus, M.A., F.R.S.E. The University, Glasgow.
1884. ‡McLennan, Frank. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, Hugh. 317 Drummond-street, Montreal, Canada.
1884. ‡McLennan, John. Lancaster, Ontario, Canada.
1868. §McLEOD, HERBERT, F.R.S., F.C.S., Professor of Chemistry in the Royal Indian Civil Engineering College, Cooper's Hill, Staines.
1892. ‡*Macleod, Reginald. Woodhall, Midlothian.*
1892. ‡Macleod, W. Bowman. 16 George-square, Edinburgh.
1861. *Maclure, John William, M.P., F.R.G.S., F.S.S. Whalley Range, Manchester.
1883. *McMAHON, Lieut.-General C. A., F.G.S. 20 Nevern-square, South Kensington, London, S.W.
1883. ‡MACMAHON, Major P. A., R.A., F.R.S., Professor of Electricity in the Artillery College, Woolwich. 52 Shaftesbury-avenue, London, W.C.
1878. *M'Master, George, M.A., J.P. Rathmines, Ireland.
1862. ‡Macmillan, Alexander. 21 Portland-place, London, W.
1888. ‡*McMillan, Robert. Australia.*

Year of Election.

1874. ‡MacMordie, Hans, M.A. 8 Donegall-street, Belfast.
1884. ‡McMurrick, J. Playfair. Cincinnati, Ohio, U.S.A.
1867. ‡M'Neill, John. Balhousie House, Perth.
1883. ‡McNicoll, Dr. E. D. 15 Manchester-road, Southport.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1887. ‡Maconochie, Archibald White. Care of Messrs. Maconochie Bros., Lowestoft.
1883. ‡Macpherson, J. 44 Frederick-street, Edinburgh.
*MACRORY, EDMUND, M.A. 19 Pembridge-square, London, W.
1883. ‡*McWhirter, William.* 170 *Kent-road, Glasgow.*
1887. ‡Macy, Jesse. Grinnell, Iowa, U.S.A.
1883. ‡Madden, W. H. Marlborough College, Wilts.
1883. ‡Maggs, Thomas Charles, F.G.S. 56 Clarendon-villas, West Brighton.
1868. ‡Magnay, F. A. Drayton, near Norwich.
1875. *Magnus, Sir Philip, B.Sc. 48 Gloucester-place, Portman-square, London, W.
1878. ‡Mahony, W. A. 34 College-green, Dublin.
1869. ‡Main, Robert. The Admiralty, Whitehall, London, S.W.
1887. ‡Mainprice, W. S. Longcroft, Altrincham, Cheshire.
1885. *Maitland, Sir James R. G., Bart., F.G.S. Stirling, N.B.
1883. ‡Maitland, P. C. 136 Great Portland-street, London, W.
*Malcolm, Frederick. Morden College, Blackheath, London, S.E.
1881. ‡Malcolm, Lieut.-Colonel, R.E. 72 Nunthorpe-road, York.
1874. ‡Malcolmson, A. B. Friends' Institute, Belfast.
1889. ‡Maling, C. T. 14 Ellison-place, Newcastle-upon-Tyne.
1857. ‡MALLET, JOHN WILLIAM, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, Albemarle Co., U.S.A.
1887. ‡MANCHESTER, The Right Rev. the Lord Bishop of, D.D. Bishop's Court, Manchester.
1870. ‡Manifold, W. H., M.D. 45 Rodney-street, Liverpool.
1885. ‡Mann, George. 72 Bon Accord-street, Aberdeen.
1888. ‡Mann, W. J. Rodney House, Trowbridge.
1894. §Manning, Percy. Watford, Herts.
1878. §Manning, Robert. 4 Upper Ely-place, Dublin.
1864. ‡Mansel-Pleydell, J. C., F.G.S. Whatcombe, Blandford.
1888. ‡Mansergh, James, M.Inst.C.E., F.G.S. 5 Victoria-street, London, S.W.
1891. ‡Manuel, James. 175 Newport-road, Cardiff.
1889. ‡Manville, E. 3 Prince's-mansions, Victoria-street, London, S.W.
1887. *March, Henry Colley, M.D., F.S.A. 2 West-street, Rochdale.
1870. ‡Marcoartu, His Excellency Don Arturo de. Madrid.
1887. ‡Margetson, J. Charles. The Rocks, Limpley, Stoke.
1883. ‡Marginson, James Fleetwood. The Mount, Fleetwood, Lancashire.
1887. §Markham, Christopher A., F.R.Met.Soc. Spratton, Northampton.
1864. ‡MARKHAM, CLEMENTS R., C.B., F.R.S., F.L.S., Pres.R.G.S., F.S.A. 21 Eccleston-square, London, S.W.
1894. §Markoff, Dr. Anatolius. 44 Museum-street, London, W.C.
1863. ‡Marley, John. Mining Office, Darlington.
1888. ‡Marling, W. J. Stanley Park, Stroud, Gloucestershire.
1888. ‡Marling, Lady. Stanley Park, Stroud, Gloucestershire.
1881. *MARR, JOHN EDWARD, M.A., F.R.S., Sec.G.S. St. John's College, Cambridge.
1887. ‡Marsden, Benjamin. Westleigh, Heaton Mersey, Manchester.
1887. ‡*Marsden, Joseph. Ardenlea, Heaton, near Bolton.*
1884. *Marsden, Samuel. St. Louis, Missouri, U.S.A.
1892. *Marsden-Smedley, J. B. Lea Green, Cromford, Derbyshire.
1883. *Marsh, Henry. Hurstwood, Roundhay, Leeds.

Year of Election.

1887. ‡Marsh, J. E., M.A. The Museum, Oxford.
1864. ‡Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
1889. *MARSHALL, ALFRED, M.A., LL.D., Professor of Political Economy in the University of Cambridge. Balliol Croft, Madingley-road, Cambridge.
1889. ‡Marshall, Frank, B.A. 31 Grosvenor-place, Newcastle-upon-Tyne.
1892. §Marshall, Hugh, D.Sc., F.R.S.E. Druim Shellach, Liberton, Midlothian.
1881. *Marshall, John, F.R.A.S., F.G.S. Church Institute, Leeds.
1890. ‡Marshall, John. Derwent Island, Keswick.
1881. ‡Marshall, John Ingham Fearby. 28 St. Saviourgate, York.
1858. ‡*Marshall, Reginald Dykes. Adel, near Leeds.*
1886. *MARSHALL, WILLIAM BAYLEY, M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1849. *MARSHALL, WILLIAM P., M.Inst.C.E. Richmond Hill, Edgbaston, Birmingham.
1865. §MARTEN, EDWARD BINDON. Pedmore, near Stourbridge.
1883. ‡Marten, Henry John. 4 Storey's-gate, London, S.W.
1887. *Martin, Rev. H. A. Laxton Vicarage, Newark.
1891. *Martin, Edward P., J.P. Dowlais, Glamorgan.
1848. ‡Martin, Henry D. 4 Imperial-circus, Cheltenham.
1878. ‡MARTIN, H. NEWELL, M.A., M.D., D.Sc., F.R.S. Physiological Laboratory, Cambridge.
1883. *MARTIN, JOHN BIDDULPH, M.A., F.S.S. 17 Hyde Park-gate, London, S.W.
1884. §Martin, N. H., F.L.S. 8 Windsor-crescent, Newcastle-upon-Tyne.
1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Lyon House, New Barnet, Herts.
1890. §Martindale, William. 19 Devonshire-street, Portland-place, London, W.
*Martineau, Rev. James, LL.D., D.D. 35 Gordon-square, London, W.C.
1865. ‡Martineau, R. F. 18 Highfield-road, Edgbaston, Birmingham.
1883. ‡Marwick, Sir James, LL.D. Killermont, Maryhill, Glasgow.
1891. ‡Marychurch, J. G. 46 Park-street, Cardiff.
1878. ‡Masaki, Taiso. Japanese Consulate, 84 Bishopsgate-street Within, London, E.C.
1847. ‡MASKELYNE, NEVIL STORY, M.A., F.R.S., F.G.S., Professor of Mineralogy in the University of Oxford. Basset Down House, Swindon.
1886. ‡Mason, Hon. J. E. Fiji.
1879. ‡Mason, James, M.D. Montgomery House, Sheffield.
1893. *Mason, Thomas. 6 Pelham-road, Sherwood Rise, Nottingham.
1891. *Massey, William H., M.Inst.C.E. Twyford, R.S.O., Berkshire.
1885. ‡Masson, Orme, D.Sc. 58 Great King-street, Edinburgh.
1883. ‡Mather, Robert V. Birkdale Lodge, Birkdale, Southport.
1887. *Mather, William, M.Inst.C.E. Salford Iron Works, Manchester.
1890. ‡Mathers, J. S. 1 Hanover-square, Leeds.
1865. ‡Mathews, C. E. Waterloo-street, Birmingham.
1894. §§Mathews, G. B. Bangor.
1865. *Mathews, G. S. 32 Augustus-road, Edgbaston, Birmingham.
1889. ‡Mathews, John Hitchcock. 1 Queen's-gardens, Hyde Park, London, W.
1861. *MATHEWS, WILLIAM, M.A., F.G.S. 21 Augustus-road, Edgbaston, Birmingham.
1881. ‡Mathwin, Henry, B.A. Bickerton House, Southport.
1883. ‡Mathwin, Mrs. 40 York-road, Birkdale, Southport.

Year of Election.

1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
1885. ‡MATTHEWS, JAMES. Springhill, Aberdeen.
1885. ‡Matthews, J. Duncan. Springhill, Aberdeen.
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-upon-Tyne.
1890. ‡*Maund, E. A. 294 Regent-street, London, W.*
1893.§§Mavor, Professor James. University of Toronto, Canada.
1865. *MAW, GEORGE, F.L.S., F.G.S., F.S.A. Benthall, Kenley, Surrey.
1894. §Maxim, Hiram S. 18 Queen's Gate-place, Kensington, S.W.
1876. ‡Maxton, John. 6 Belgrave-terrace, Glasgow.
1887. ‡Maxwell, James. 29 Princess-street, Manchester.
*Maxwell, Robert Perceval. Finnebrogue, Downpatrick.
1883. §May, William, F.G.S., F.R.G.S. Northfield, St. Mary Cray, Kent.
1883. ‡Mayall, George. Clairville, Birkdale, Southport.
1884. *Maybury, A. C., D.Sc. 19 Bloomsbury-square, London, W.C.
1878. *Mayne, Thomas. 33 Castle-street, Dublin.
1884. ‡*Mecham, Arthur. 11 Newton-terrace, Glasgow.*
1871. ‡Meikie, James, F.S.S. 6 St. Andrew's-square, Edinburgh.
1879. §Meiklejohn, John W. S., M.D. 105 Holland-road, London, W.
1887. ‡Meischke-Smith, W. Rivala Lumpore, Salengore, Straits Settlements.
1881. *MELDOLA, RAPHAEL, F.R.S., F.R.A.S., F.C.S., F.I.C., Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, London, W.C.
1867. ‡MELDRUM, CHARLES, C.M.G., LL.D., F.R.S., F.R.A.S. Port Louis, Mauritius.
1883. ‡Mellis, Rev. James. 23 Park-street, Southport.
1879. *Mellish, Henry. Hodsock Priory, Worksop.
1866. ‡MELLO, Rev. J. M., M.A., F.G.S. Mapperley Vicarage, Derby.
1883. §Mello, Mrs. J. M. Mapperley Vicarage, Derby.
1881. §Melrose, James. Clifton Croft, York.
1887. ‡Melvill, J. Cosmo, M.A. Kersal Cottage, Prestwich, Manchester.
1847. ‡Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. ‡Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1877. *Menabrea, General, Marquis of Valdora, LL.D. Chambéry, Savoie.
1862. ‡MENNELL, HENRY T. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1879. §MERIVALE, JOHN HERMAN, M.A. Togston Hall, Acklington, Northumberland.
1880. ‡Merry, Alfred S. Bryn Heulog, Sketty, near Swansea.
1889. *Merz, John Theodore. The Quarries, Newcastle-upon-Tyne.
1863. ‡Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1869. ‡MIALL, LOUIS C., F.R.S., F.L.S., F.G.S., Professor of Biology in the Yorkshire College, Leeds.
1886. ‡Middlemore, Thomas. Holloway Head, Birmingham.
1865. ‡Middlemore, William. Edgbaston, Birmingham.
1881. *Middlesbrough, The Right Rev. Richard Lacy, D.D., Bishop of Middlesbrough.
1893. §Middleton, A. 25 Lister-gate, Nottingham.
1881. ‡Middleton, R. Morton, F.L.S., F.Z.S. 15 Grange-road, West Hartlepool.
1894. *Miers, H. A., M.A., F.G.S. British Museum, Cromwell-road, London, S.W.
1889. ‡Milburn, John D. Queen-street, Newcastle-upon-Tyne.
1886. ‡Miles, Charles Albert. Buenos Ayres.
1881.§§MILES, MORRIS. Warbourne, Hill-lane, Southampton.
1885. §MILL, HUGH ROBERT, D.Sc., F.R.S.E., Librarian R.G.S. 109 West End-lane, Hampstead, London, N.W.
1859. ‡Millar, John, J.P. Lisburn, Ireland.

Year of Election.

1889. *Millar, Robert Cockburn. 30 York-place, Edinburgh.
Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.
1892. *Millard, William Joseph Kelson, M.D., F.R.G.S. Holmleigh, Rockleaze, Stoke Bishop, Bristol.
1882. ‡Miller, A. J. 15 East Park-terrace, Southampton.
1875. ‡Miller, George. Brentry, near Bristol.
1895. §Miller, Henry, M.Inst.C.E. Bosmere House, Norwich-road, Ipswich.
1892. ‡Miller, Hugh, F.R.S.E., F.G.S. 3 Douglas-crescent, Edinburgh.
1888. ‡Miller, J. Bruce. Rubislaw Den North, Aberdeen.
1885. ‡Miller, John. 9 Rubislaw-terrace, Aberdeen.
1886. ‡Miller, Rev. John, B.D. The College, Weymouth.
1861. *Miller, Robert. Totteridge House, Hertfordshire, N.
1884. ‡Miller, T. F., B.Ap.Sc. Napanee, Ontario, Canada.
1895. §Miller, Thomas, M.Inst.C.E. 4 Butter-market, Ipswich.
1876. ‡Miller, Thomas Paterson. Cairns, Cambuslang, N.B.
1868. *MILLS, EDMUND J., D.Sc., F.R.S., F.C.S., Young Professor of Technical Chemistry in the Glasgow and West of Scotland Technical College, Glasgow. 60 John-street, Glasgow.
1880. §Mills, Mansfeldt H., M.Inst.C.E., F.G.S. Mansfield Woodhouse, Mansfield.
1834. Milne, Admiral Sir Alexander, Bart., G.C.B., F.R.S.E. Inveresk.
1885. ‡Milne, Alexander D. 40 Albyn-place, Aberdeen.
1882. *MILNE, JOHN, F.R.S., F.G.S. Shide Hill House, Shide, Isle of Wight.
1885. ‡Milne, J. D. 14 Rubislaw-terrace, Aberdeen.
1885. ‡Milne, William. 40 Albyn-place, Aberdeen.
1887. ‡Milne-Redhead, R., F.L.S. Holden Clough, Clitheroe.
1882. ‡Milnes, Alfred, M.A., F.S.S. 22A Goldhurst-terrace, South Hampstead, London, N.W.
1880. ‡MINCHIN, G. M., M.A., F.R.S. Royal Indian Engineering College, Cooper's Hill, Surrey.
1855. ‡Mirrlees, James Buchanan. 45 Scotland-street, Glasgow.
1859. ‡Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1876. ‡Mitchell, Andrew. 20 Woodside-place, Glasgow.
1883. ‡Mitchell, Charles T., M.A. 41 Addison-gardens North, Kensington, London, W.
1883. ‡Mitchell, Mrs. Charles T. 41 Addison-gardens North, Kensington, London, W.
1873. ‡Mitchell, Henry. Parkfield House, Bradford, Yorkshire.
1885. ‡Mitchell, Rev. J. Mitford, B.A. 6 Queen's-terrace, Aberdeen.
1885. ‡Mitchell, P. Chalmers. Christ Church, Oxford.
1879. ‡MIVART, ST. GEORGE, Ph.D., M.D., F.R.S., F.L.S., F.Z.S. Hurstcote, Chilworth, Surrey.
1895. *Moat, William, M.A. Johnson, Eccleshall, Staffordshire.
1885. ‡Moffat, William. 7 Queen's-gardens, Aberdeen.
1885. ‡Moir, James. 25 Carden-place, Aberdeen.
1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1878. ‡Molloy, Constantine, Q.C. 65 Lower Leeson-street, Dublin.
1877. *Molloy, Rev. Gerald, D.D. 86 Stephen's-green, Dublin.
1884. ‡Monaghan, Patrick. Halifax (Box 317), Nova Scotia, Canada.
1887. *MOND, LUDWIG, Ph.D., F.R.S., F.C.S. 20 Avenue-road, Regent's Park, London, N.W.
1891. *Mond, Robert Ludwig, B.A., F.R.S.E., F.G.S. 20 Avenue-road, Regent's Park, London, N.W.
1882. *Montagu, Sir Samuel, Bart., M.P. 12 Kensington Palace-gardens, London, W.
1891. ‡Montefiore, Arthur, F.G.S., F.R.G.S. Care of London and South-Western Bank, South Hampstead, London, N.W.

Year of
Election.

1892. ‡Montgomery, Very Rev. J. F., D.D. 17 Athole-crescent, Edinburgh.
1872. ‡Montgomery, R. Mortimer. 3 Porchester-place, Edgware-road, London, W.
1872. ‡Moon, W., LL.D. 104 Queen's-road, Brighton.
1884. ‡Moore, George Frederick. 49 Hardman-street, Liverpool.
1894. §Moore, H. E. 41 Bedford-row, London, W.C.
1891. ‡Moore, John. Lindenwood, Park-place, Cardiff.
1890. ‡Moore, Major, R.E. School of Military Engineering, Chatham.
*Moore, John Carrick, M.A., F.R.S., F.G.S. 113 Eaton-square, London, S.W.; and Corswall, Wigtonshire.
1857. *Moore, Rev. William Prior. Carrickmore, Galway, Ireland.
1891. ‡Morel, P. Lavernock House, near Cardiff.
1881. ‡Morgan, Alfred. 50 West Bay-street, Jacksonville, Florida, U.S.A.
1895. §Morgan, C. Lloyd, F.G.S., Principal of University College, Bristol. 16 Canynge-road, Clifton, Bristol.
1873. ‡Morgan, Edward Delmar, F.R.G.S. 15 Roland-gardens, London, S.W.
1891. ‡Morgan, F. Forest Lodge, Ruspidge, Gloucestershire.
1885. ‡*Morgan, John. 57 Thomson-street, Aberdeen.*
1887. ‡Morgan, John Gray. 38 Lloyd-street, Manchester.
1882. §§Morgan, Thomas. Cross House, Southampton.
1889. §Morison, J. Rutherford, M.D. 14 Saville-row, Newcastle-upon-Tyne.
1892. ‡Morison, John, M.D., F.G.S. Victoria-street, St. Albans.
1867. ‡Morison, William R. Dundee.
1893. §§Morland, John, J.P. Glastonbury.
1895. §Morley, Edward W. Cleveland, Ohio, U.S.A.
1891. ‡Morley, H. The Gas Works, Cardiff.
1883. *Morley, Henry Forster, M.A., D.Sc., F.C.S. 47 Broadhurst-gardens, South Hampstead, London, N.W.
1889. ‡Morley, The Right Hon. John, M.A., LL.D., F.R.S. 95 Elm Park-gardens, London, S.W.
1881. ‡Morrell, W. W. York City and County Bank, York.
1880. ‡Morris, Alfred Arthur Vennor. Wernolau, Cross Inn, R.S.O., Carmarthenshire.
1883. ‡Morris, C. S. Millbrook Iron Works, Landore, South Wales.
1892. ‡Morris, Daniel, C.B., M.A., F.L.S. 11 Kew Gardens-road, Kew.
1883. ‡Morris, George Lockwood. Millbrook Iron Works, Swansea.
1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.
1883. ‡Morris, John. 4 The Elms, Liverpool.
1888. ‡Morris, J. W., F.L.S. The Woodlands, Bathwick Hill, Bath.
1880. ‡*Morris, M. I. E. The Lodge, Penclawdd, near Swansea.*
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1876. ‡Morris, Rev. S. S. O., M.A., R.N., F.C.S. H.M.S. 'Garnet,' S. Coast of America.
1874. ‡Morrison, G. J., M.Inst.C.E. Shanghai, China.
1890. ‡Morrison, Sir George W. Leeds.
1871. *Morrison, James Darsie. 27 Grange-road, Edinburgh.
1886. ‡Morrison, John T. Scottish Marine Station, Granton, N.B.
1865. ‡Mortimer, J. R. St. John's-villas, Driffield.
1869. ‡Mortimer, William. Bedford-circus, Exeter.
1857. §Morton, George H., F.G.S. 209 Edge-lane, Liverpool.
1858. *Morton, Henry Joseph. 2 Westbourne-villas, Scarborough.
1871. ‡Morton, Hugh. Belvedere House, Trinity, Edinburgh.
1887. ‡Morton, Percy, M.A. Illtyd House, Brecon, South Wales.

Year of Election.

1886. *Morton, P. F. Hook House, Hook, near Winchfield, Hampshire.
1883. ‡Moseley, Mrs. Firwood, Clevedon, Somerset.
1878. *Moss, John Francis, F.R.G.S. Beechwood, Brincliffe, Sheffield.
1876. §§Moss, Richard Jackson, F.C.S., M.R.I.A. St. Aubyn's, Ballybrack, Co. Dublin.
1864. *Mosse, J. R. 5 Chiswick-place, Eastbourne.
1892. ‡Mossman, R. C., F.R.S.E. 10 Blacket-place, Edinburgh.
1873. ‡Mossman, William. Ovenden, Halifax.
1892. *Mostyn, S. G., B.A. Colet House, Talgarth-road, London, W.
1869. §Mott, Albert J., F.G.S. Detmore, Charlton Kings, Cheltenham.
1866. §Mott, Frederick T., F.R.G.S. Crescent House, Leicester.
1862. *Mouat, Frederick John, M.D., Local Government Inspector. 12 Durham-villas, Campden Hill, London, W.
1856. ‡Mould, Rev. J. G., B.D. Roseland, Meadfoot, Torquay.
1878. *Moulton, J. Fletcher, M.A., Q.C., F.R.S. 57 Onslow-square, London, S.W.
1863. ‡Mounsey, Edward. Sunderland.
1861. *Mountcastle, William Robert. The Wigwam, Ellenbrook, near Manchester.
1877. ‡Mount-Edgcumbe, The Right Hon. the Earl of, D.C.L. Mount-Edgcumbe, Devonport.
1887. ‡Moxon, Thomas B. County Bank, Manchester.
1888. ‡Moyle, R. E., B.A., F.C.S. The College, Cheltenham.
1884. ‡Moyse, C. E., B.A., Professor of English Language and Literature in McGill College, Montreal. 802 Sherbrooke-street, Montreal, Canada.
1884. ‡Moyse, Charles E. 802 Sherbrooke-street, Montreal, Canada.
1894. §§Mugliston, Rev. J., M.A. Newick House, Cheltenham.
1876. *Muir, Sir John, Bart. Demster House, Perthshire.
1874. ‡Muir, M. M. Pattison, M.A. Caius College, Cambridge.
1876. ‡Muir, Thomas, M.A., LL.D., F.R.S.E. Beechcroft, Bothwell, Glasgow.
1872. ‡Muirhead, Alexander, D.Sc., F.C.S. 2 Prince's-street, Storey's-gate, Westminster, S.W.
1876. *Muirhead, Robert Franklin, M.A., B.Sc. 59 Warrender Park-road, Edinburgh.
1884. **Muirhead-Paterson, Miss Mary. Laurieville, Queen's Drive, Crosshill, Glasgow.*
1883. ‡Mulhall, Michael G. Fancourt, Balbriggan, Co. Dublin.
1883. ‡Mulhall, Mrs. Marion. Fancourt, Balbriggan, Co. Dublin.
1891. §§Müller, F. Max, M.A., Professor of Comparative Philology in the University of Oxford. 7 Norham-gardens, Oxford.
1884. *Müller, Hugo, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, London, N.W.
1880. ‡Muller, Hugo M. 1 Grünanger-gasse, Vienna.
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. ‡Mundella, The Right Hon. A. J., M.P., F.R.S. 16 Elvaston-place, London, S.W.
1876. ‡Munro, Donald, F.C.S. The University, Glasgow.
1885. ‡Munro, J. E. Crawford, LL.D. 14 Upper Cheyne-row, Chelsea, London, S.W.
1883. *Munro, Robert, M.A., M.D. 48 Manor-place, Edinburgh.
1864. *Murchison, K. R. Brockhurst, East Grinstead.
1855. ‡Murdoch, James Barclay. Capelrig, Mearns, Renfrewshire.
1890. ‡Murphy, A. J. Preston House, Leeds.
1889. ‡Murphy, James, M.A., M.D. Holly House, Sunderland.
1884. §Murphy, Patrick. Newry, Ireland.

Year of Election.

1887. ‡Murray, A. Hazeldean, Kersal, Manchester.
1891. ‡Murray, G. R. M., F.R.S.E., F.L.S. British Museum (Natural History), South Kensington, London, S.W.
1859. ‡Murray, John, M.D. Forres, Scotland.
1884. ‡MURRAY, JOHN, LL.D., Ph.D., F.R.S.E. 'Challenger' Expedition Office, Edinburgh.
1884. ‡Murray, J. Clark, LL.D., Professor of Logic and Mental and Moral Philosophy in McGill University, Montreal. 111 McKay-street, Montreal, Canada.
1872. ‡Murray, J. Jardine, F.R.C.S.E. 99 Montpellier-road, Brighton.
1892. ‡Murray, T. S. 1 Nelson-street, Dundee.
1863. ‡Murray, William, M.D. 9 Ellison-place, Newcastle-on-Tyne.
1883. ‡Murray, W. Vaughan, F.R.G.S. 2 Savile-row, London, W.
1874. §Musgrave, James, J.P. Drumglass House, Belfast.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1891. §§Muybridge, Eadweard. University of Pennsylvania, Philadelphia, U.S.A.
1890. *Myres, John L., M.A., F.S.A. Christ Church, Oxford.

1886. §NAGEL, D. H., M.A., F.C.S. Trinity College, Oxford.
1892. *Nairn, Michael B. Kirkcaldy, N.B.
1890. §Nalder, Francis Henry. 16 Red Lion-street, Clerkenwell, London, E.C.
1876. ‡Napier, James S. 9 Woodside-place, Glasgow.
1872. ‡NARES, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. St. Bernard's, Maple-road, Surbiton.
1887. ‡Nason, Professor Henry B., Ph.D., F.C.S. Troy, New York, U.S.A.
1887. §Neild, Charles. 19 Chapel Walks, Manchester.
1883. *Neild, Theodore, B.A. Dalton Hall, Manchester.
1887. ‡Neill, Joseph S. Claremont, Broughton Park, Manchester.
1887. ‡Neill, Robert, jun. Beech Mount, Higher Broughton, Manchester.
1855. ‡Neilson, Walter. 172 West George-street, Glasgow.
1876. ‡*Nelson, D. M.* 11 *Bothwell-street, Glasgow.*
1886. ‡*Nettlefold, Edward.* 51 *Carpenter-road, Edgbaston, Birmingham.*
1868. ‡Nevill, Rev. H. R. The Close, Norwich.
1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.
1889. †Neville, F. H. Sidney College, Cambridge.
1869. ‡Nevins, John Birkbeck, M.D. 3 Abercromby-square, Liverpool.
1842. New, Herbert. Evesham, Worcestershire.
1889. *Newall, H. Frank. Madingley Rise, Cambridge.
1891. *Newell, W. H. A. 10 Plasturton-gardens, Cardiff.
1886. ‡Newbolt, F. G. Edenhurst, Addlestone, Surrey.
1842. *NEWMAN, Professor FRANCIS WILLIAM. 15 Arundel-crescent, Weston-super-Mare.
1889. §§Newstead, A. H. L., B.A. Roseacre, Epping.
1860. *NEWTON, ALFRED, M.A., F.R.S., F.L.S., Professor of Zoology and Comparative Anatomy in the University of Cambridge. Magdalene College, Cambridge.
1892. ‡NEWTON, E. T., F.R.S., F.G.S. Geological Museum, Jermyn-street, London, S.W.
1872. ‡Newton, Rev. J. 125 Eastern-road, Brighton.
1883. ‡Nias, Miss Isabel. 56 Montagu-square, London, W.
1882. ‡Nias, J. B., B.A. 56 Montagu-square, London, W.
1867. ‡Nicholl, Thomas. Dundee.
1875. ‡Nicholls, J. F. City Library, Bristol.

Year of Election.

1866. ‡NICHOLSON, Sir CHARLES, Bart., M.D., D.C.L., LL.D., F.G.S., F.R.G.S. The Grange, Totteridge, Herts.
1867. ‡NICHOLSON, HENRY ALLEYNE, M.D., D.Sc., F.G.S., Professor of Natural History in the University of Aberdeen.
1887. *Nicholson, John Carr. Moorfield House, Headingley, Leeds.
1884. ‡NICHOLSON, JOSEPH S., M.A., D.Sc., Professor of Political Economy in the University of Edinburgh. Eden Lodge, Newbattle-terrace, Edinburgh.
1883. ‡Nicholson, Richard, J.P. Whinfield, Hesketh Park, Southport.
1887. ‡Nicholson, Robert H. Bourchier. 21 Albion-street, Hull.
1881. ‡Nicholson, William R. Clifton, York.
1893. ‡Nickolls, John B., F.C.S. The Laboratory, Guernsey.
1887. ‡Nickson, William. Shelton, Sibson-road, Sale, Manchester.
1885. §Nicol, W. W. J., M.A., D.Sc., F.R.S.E. 15 Blacket-place, Edinburgh.
1878. ‡NIVEN, CHARLES, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy in the University of Aberdeen. 6 Chanonry, Aberdeen.
1886. ‡*Niven, George. Erkingholme, Coolhurst-road, London, N.*
1877. ‡Niven, Professor James, M.A. King's College, Aberdeen.
1874. ‡Nixon, Randal C. J., M.A. Royal Academical Institution, Belfast.
1884. ‡Nixon, T. Alcock. 33 Harcourt-street, Dublin.
1863. *NOBLE, Sir ANDREW, K.C.B., F.R.S., F.R.A.S., F.C.S. Elswick Works, and Jesmond Dene House, Newcastle-upon-Tyne.
1879. ‡Noble, T. S., F.G.S. Lendal, York.
1886. ‡Nock, J. B. Mayfield, Penns, near Birmingham.
1887. ‡Nodal, John H. The Grange, Heaton Moor, near Stockport.
1870. ‡Nolan, Joseph, M.R.I.A. 14 Hume-street, Dublin.
1863. §NORMAN, Rev. Canon ALFRED MERLE, M.A., D.C.L., F.R.S., F.L.S. Burnmoor Rectory, Fence Houses, Co. Durham.
1888. ‡Norman, George. 12 Brock-street, Bath.
1865. ‡NORRIS, RICHARD, M.D. 2 Walsall-road, Birchfield, Birmingham.
1872. ‡Norris, Thomas George. Gorphwysfa, Llanrwst, North Wales.
1883. *Norris, William G. Coalbrookdale, Shropshire.
1881. ‡North, William, B.A., F.C.S. 84 Micklegate, York.
NORTON, The Right Hon. Lord, K.C.M.G. 35 Eaton-place, London, S.W.; and Hamshall, Birmingham.
1886. ‡Norton, Lady. 35 Eaton-place, London, S.W.; and Hamshall, Birmingham.
1894. §NOTCUTT, S. A., LL.M., B.A., B.Sc. 9 Museum-street, Ipswich.
1861. ‡Noton, Thomas. Priory House, Oldham.
Nowell, John. Farnley Wood, near Huddersfield.
1887. ‡Nursey, Perry Fairfax. 2 Trafalgar-buildings, Northumberland-avenue, London, W.C.

1882. §Obach, Eugene, Ph.D. 2 Victoria-road, Old Charlton, Kent.
O'Callaghan, George. Tallas, Co. Clare.
1878. ‡O'Conor Don, The. Clonalis, Castlerea, Ireland.
1883. ‡Odgers, William Blake, M.A., LL.D. 4 Elm-court, Temple, London, E.C.
1858. *ODLING, WILLIAM, M.B., F.R.S., F.C.S., Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.
1884. ‡Odlum, Edward, M.A. Pembroke, Ontario, Canada.
1857. ‡O'Donnavan, William John. 54 Kenilworth-square, Rathgar, Dublin.

Year of Election.

1894. §Ogden, James. Kilner Deyne, Rochdale.
1885. ‡Ogilvie, Alexander, LL.D. Gordon's College, Aberdeen.
1876. ‡Ogilvie, Campbell P. Sizewell House, Leiston, Suffolk.
1885. ‡OGILVIE, F. GRANT, M.A., B.Sc., F.R.S.E. Heriot Watt College, Edinburgh.
1893. ‡Ogilvie, Miss Maria M., D.Sc. Gordon's College, Aberdeen.
1859. ‡Ogilvy, Rev. C. W. Norman. Baldan House, Dundee.
*Ogle, William, M.D., M.A. The Elms, Derby.
1884. ‡O'Halloran, J. S., C.M.G., F.R.G.S. Royal Colonial Institute, Northumberland-avenue, London, W.C.
1881. ‡Oldfield, Joseph. Lendal, York.
1887. ‡Oldham, Charles. Syrian House, Sale, near Manchester.
1892.§§Oldham, H. Yule, M.A., F.R.GS., Lecturer in Geography in the University of Cambridge. King's College, Cambridge.
1853. ‡OLDHAM, JAMES, M.Inst.C.E. Cottingham, near Hull.
1885. ‡Oldham, John. River Plate Telegraph Company, Monte Video.
1893.§§Oldham, R. D., F.G.S., Geological Survey of India. Care of Messrs. H. S. King & Co., Cornhill, London, E.C.
1892. ‡Oliphant, James. 50 Palmerston-place, Edinburgh.
1863. ‡OLIVER, DANIEL, LL.D., F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. 10 Kew Gardens-road, Kew.
1887. ‡Oliver, Professor F. W., D.Sc. 10 Kew Gardens-road, Kew, Surrey.
1883. ‡Oliver, J. A. Westwood. The Liberal Club, Glasgow.
1883. §Oliver, Samuel A. Bellingham House, Wigan, Lancashire.
1889. §Oliver, Professor T., M.D. 7 Ellison-place, Newcastle-upon-Tyne.
1882. §Olsen, O. T., F.R.A.S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.
1860. *OMMANNEY, Admiral Sir ERASMUS, C.B., LL.D., F.R.S., F.R.A.S., F.R.G.S. 29 Connaught-square, Hyde Park, London, W.
1880. *Ommanney, Rev. E. A. St. Michael's and All Angels, Portsea, Hants.
1887. ‡*O'Neill, Charles. Glen Allan, Manley-road, Alexandra Park, Manchester.*
1872. ‡Onslow, D. Robert. New University Club, St. James's, London, S.W.
1883. ‡Oppert, Gustav, Professor of Sanskrit. Madras.
1867. ‡Orchar, James G. 9 William-street, Forebank, Dundee.
1883. ‡Ord, Miss Maria. Fern Lea, Park-crescent, Southport.
1883. ‡Ord, Miss Sarah. 2 Pembroke-vale, Clifton, Bristol.
1880. ‡O'Reilly, J. P., Professor of Mining and Mineralogy in the Royal College of Science, Dublin.
1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester.
1858. ‡Ormerod, T. T. Brighouse, near Halifax.
1883. ‡Orpen, Miss. 58 Stephen's-green, Dublin.
1884. *Orpen, Lieut.-Colonel R. T., R.E. Care of G. H. Orpen, Esq., Erpingham, Bedford Park, Chiswick, London.
1884. *Orpen, Rev. T. H., M.A. Binnbrooke, Cambridge.
1838. Orr, Alexander Smith. 57 Upper Sackville-street, Dublin.
1873. ‡*Osborn, George. 47 Kingscross-street, Halifax.*
1887. §O'Shea, L. T., B.Sc. Firth College, Sheffield.
*OSLER, A. FOLLETT, F.R.S. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. Coppy Hill, Linthurst, near Bromsgrove, Birmingham.
1869. **Osler, Sidney F. Chesham Lodge, Lower Norwood, Surrey, S.E.*
1884. ‡Osler, William, M.D., Professor of the Institutes of Medicine in McGill University, Montreal, Canada.
1884. ‡O'Sullivan, James, F.C.S. 71 Spring Terrace-road, Burton-on-Trent.

Year of Election.

1882. *Oswald, T. R. Castle Hall, Milford Haven.
1881. *Ottewell, Alfred D. Brass Foundry, Traffic-street, Siddals-road, Derby.
1882. ‡Owen, Rev. C. M., M.A. St. George's, Edgbaston, Birmingham.
1889. *Owen, Alderman H. C. Compton, Wolverhampton.
1888. *Owen, Thomas. 8 Alfred-street, Bath.
1877. ‡Oxland, Dr. Robert, F.C.S. 8 Portland-square, Plymouth.

1889. ‡Page, Dr. F. 1 Saville-place, Newcastle-upon-Tyne.
1883. ‡Page, George W. Fakenham, Norfolk.
1883. ‡Page, Joseph Edward. 12 Saunders-street, Southport.
1872. *Paget, Joseph. Stuffynwood Hall, Mansfield, Nottingham.
1894. §§Paget, Octavius. 158 Fenchurch-street, London, E.C.
1884. ‡Paine, Cyrus F. Rochester, New York, U.S.A.
1875. ‡Paine, William Henry, M.D., F.G.S. Stroud, Gloucestershire.
1870. *PALGRAVE, R. H. INGLIS, F.R.S., F.S.S. Belton, Great Yarmouth.
1883. ‡Palgrave, Mrs. R. H. Inglis. Belton, Great Yarmouth.
1889. ‡PALMER, Sir CHARLES MARK, Bart., M.P. Grinkle Park, Yorkshire.
1873. ‡Palmer, George. The Acacias, Reading, Berks.
1878. *Palmer, Joseph Edward. 8 Upper Mount-street, Dublin.
1866. §Palmer, William. Waverley House, Waverley-street, Nottingham.
1872. **Palmer, W. R. 1 The Cloisters, Temple, E.C.*
Palmes, Rev. William Lindsay, M.A. Naburn Hall, York.
1890. ‡*Pankhurst, R. M., LL.D. 8 Russell-square, London, W.C.*
1883. §Pant, F. J. Van der. Clifton Lodge, Kingston-on-Thames.
1886. ‡Panton, George A., F.R.S.E. 73 Westfield-road, Edgbaston, Birmingham.
1884. ‡Panton, Professor J. Hoyes, M.A., F.G.S. Ontario Agricultural College, Guelph, Ontario, Canada.
1883. ‡Park, Henry. Wigan.
1883. ‡Park, Mrs. Wigan.
1880. *Parke, George Henry, F.L.S., F.G.S. St. John's, Wakefield, Yorkshire.
1863. ‡Parker, Henry. Low Elswick, Newcastle-upon-Tyne.
1874. ‡*Parker, Henry R., LL.D. Methodist College, Belfast.*
1886. ‡Parker, Lawley. Chad Lodge, Edgbaston, Birmingham.
1891. ‡Parker, William Newton, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff.
1865. *Parkes, Samuel Hickling, F.L.S. Ashfield-road, King's Heath, Birmingham.
1879. ‡Parkin, William. The Mount, Sheffield.
1887. §Parkinson, James. Station-road, Turton, Bolton.
1859. ‡Parkinson, Robert, Ph.D. Yewbarrow House, Grange-over-Sands.
1862. *Parnell, John, M.A. Hadham House, Upper Clapton, London, N.E.
1883. ‡Parson, T. Cooke, M.R.C.S. Atherston House, Clifton, Bristol.
1877. ‡Parson, T. Edgcumbe. 36 Torrington-place, Plymouth.
1865. *Parsons, Charles Thomas. Mountlands, Norfolk-road, Edgbaston, Birmingham.
1878. ‡Parsons, Hon. C. A. Elvaston Hall, Newcastle-upon-Tyne.
1883. ‡Part, Isabella. Rudleth, Watford, Herts.
1875. ‡Pass, Alfred C. Rushmere House, Durdham Down, Bristol.
1881. ‡Patchitt, Edward Cheshire. 128 Derby-road, Nottingham.
1887. ‡Paterson, A. M., M.D., Professor of Anatomy in University College, Liverpool.
1884. *Paton, David. Johnstone, Scotland.

Year of Election.

1883. *Paton, Henry, M.A. 15 Myrtle-terrace, Edinburgh.
1884. *Paton, Hugh. 911 Sherbrooke-street, Montreal, Canada.
1883. ‡*Paton, Rev. William. The Ferns, Parkside, Nottingham.*
1871. *Patterson, A. Henry. 16 Ashburn-place, London, S.W.
1884. ‡*Patterson, Edward Mortimer. Fredericton, New Brunswick, Canada.*
1876. ‡Patterson, T. L. Maybank, Greenock.
1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast.
1863. ‡PATTINSON, JOHN, F.C.S. 75 The Side, Newcastle-upon-Tyne.
1863. ‡Pattinson, William. Felling, near Newcastle-upon-Tyne.
1867. ‡Pattison, Samuel Rowles, F.G.S. 11 Queen Victoria-street, London, E.C.
1879. *Patzer, F. R. Stoke-on-Trent.
1863. ‡PAUL, BENJAMIN H., Ph.D. 1 Victoria-street, Westminster, S.W.
1892. ‡Paul, J. Balfour. 30 Heriot-row, Edinburgh.
1863. ‡PAVY, FREDERICK WILLIAM, M.D., F.R.S. 35 Grosvenor-street, London, W.
1887. *Paxman, James. Stisted Hall, near Braintree, Essex.
1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.
1881. ‡Payne, J. Buxton. 15 Mosley-street, Newcastle-upon-Tyne.
1877. *Payne, J. C. Charles. Botanic-avenue, The Plains, Belfast.
1881. ‡Payne, Mrs. Botanic-avenue, The Plains, Belfast.
1866. ‡Payne, Joseph F., M.D. 78 Wimpole-street, London, W.
1888. *Paynter, J. B. Hendford Manor House, Yeovil.
1886. ‡Payton, Henry. Wellington-road, Birmingham.
1876. ‡Peace, G. H. Monton Grange, Eccles, near Manchester.
1879. ‡Peace, William K. Moor Lodge, Sheffield.
1885. ‡PEACH, B. N., F.R.S., F.R.S.E., F.G.S. Geological Survey Office, Edinburgh.
1883. ‡Peacock, Ebenezer. 8 Mandeville-place, Manchester-square, London, W.
1875. ‡Peacock, Thomas Francis. 12 South-square, Gray's Inn, London, W.C.
1881. *PEARCE, HORACE, F.R.A.S., F.L.S., F.G.S. The Limes, Stourbridge.
1886. *Pearce, Mrs. Horace. The Limes, Stourbridge.
1888. §Pearce, Rev. R. J., D.C.L. Bedlington Vicarage, R.S.O., Northumberland.
1884. ‡Pearce, William. Winnipeg, Canada.
1886. ‡Pearsall, Howard D. 19 Willow-road, Hampstead, London, N.W.
1883. ‡Pearson, Arthur A. Colonial Office, London, S.W.
1891. ‡Pearson, B. Dowlais Hotel, Cardiff.
1893. *Pearson, Charles E. Chilwell House, Nottinghamshire.
1883. ‡Pearson, Miss Helen E. 69 Alexandra-road, Southport.
1892. ‡Pearson, J. M. John Dickie-street, Kilmarnock.
1881. ‡Pearson, John. Glentworth House, The Mount, York.
1883. ‡Pearson, Mrs. Glentworth House, The Mount, York.
1872. *Pearson, Joseph. Grove Farm, Merlin, Raleigh, Ontario, Canada.
1881. ‡Pearson, Richard. 57 Bootham, York.
1870. ‡*Pearson, Rev. Samuel, M.A. Highbury-quadrant, London, N.*
1883. *Pearson, Thomas H. Redclyffe, Newton-le-Willows, Lancashire.
1863. §Pease, H. F., M.P. Brinkburn, Darlington.
1889. ‡Pease, Howard. Enfield Lodge, Benwell, Newcastle-upon-Tyne.
1863. ‡Pease, Sir Joseph W., Bart., M.P. Hutton Hall, near Guisborough.
1863. ‡Pease, J. W. Newcastle-upon-Tyne.
1883. ‡Peck, John Henry. 52 Hoghton-street, Southport.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
*Peckover, Alexander, F.S.A., F.L.S., F.R.G.S. Bank House, Wisbech, Cambridgeshire.

Year of Election.

1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
1885. ‡Peddie, William, D.Sc., F.R.S.E. 2 Cameron Park, Edinburgh.
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1883. ‡PEEK, CUTHBERT E., M.A., F.S.A. 25 Bryanston-square, London, W.
1878. *Peek, William. The Manor House, Kemp Town, Brighton.
1881. ‡Peggs, J. Wallace. 21 Queen Anne's-gate, London, S.W.
1861. *Peile, George, jun. Shotley Bridge, Co. Durham.
1878. ‡Pemberton, Charles Seaton. 44 Lincoln's Inn-fields, London, W.C.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, Sir John, G.C.M.G., M.P. 18 Arlington-street, London, S.W.
1887. §PENDLEBURY WILLIAM H., M.A., F.C.S. 6 Gladstone-terrace, Priory Hill, Dover.
1894. §Pengelly, Miss. Lamorna, Torquay.
1894. §Pengelly, Miss Hester. Lamorna, Torquay.
1881. ‡Penty, W. G. Melbourne-street, York.
1875. ‡Perceval, Rev. Canon John, M.A., LL.D. Rugby.
1889. ‡Percival, Archibald Stanley, M.A., M.B. 16 Ellison-place, Newcastle-upon-Tyne.
1895. §Percival, John, M.A. The South-Eastern Agricultural College, Wye, Kent.
*Perigal, Frederick. Cambridge Cottage, Kingswood, Reigate.
1894. §§Perkin, A. G., F.R.S.E., F.C.S., F.I.C. 8 Montpelier-terrace, Woodhouse Cliff, Leeds.
1868. *PERKIN, WILLIAM HENRY, Ph.D., F.R.S., F.C.S. The Chestnuts, Sudbury, Harrow, Middlesex.
1884. ‡PERKIN, WILLIAM HENRY, jun., Ph.D., F.R.S., F.C.S., Professor of Organic Chemistry in Owens College, Manchester.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1885. ‡Perrin, Miss Emily. 31 St John's Wood Park, London, N.W.
1886. ‡Perrin, Henry S. 31 St. John's Wood Park, London, N.W.
1886. ‡Perrin, Mrs. 23 Holland Villas-road, Kensington, London, W.
1879. ‡*Perry, James. Roscommon.*
1874. *PERRY, JOHN, M.E., D.Sc., F.R.S., Professor of Engineering and Applied Mathematics in the Technical College, Finsbury. 31 Brunswick-square, London, W.C.
1883. ‡Perry, Ottley L., F.R.G.S. Bolton-le-Moors, Lancashire.
1883. ‡Perry, Russell R. 34 Duke-street, Brighton.
1883. ‡Petrie, Miss Isabella. Stone Hill, Rochdale.
1895. §PETRIE, W. M. FLINDERS, D.C.L., Professor of Egyptology in University College, London, W.C.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. 13 Fourth Avenue, Brighton.
1882. ‡Pfoundes, Charles. Spring Gardens, London, S.W.
1886. ‡Phelps, Colonel A. 23 Augustus-road, Edgbaston, Birmingham.
1884. ‡Phelps, Charles Edgar. Carisbrooke House, The Park, Nottingham.
1884. ‡Phelps, Mrs. Carisbrooke House, The Park, Nottingham.
1886. ‡Phelps, Hon. E. J. American Legation, Members' Mansions, Victoria-street, London, S.W.
1863. *PHENÉ, JOHN SAMUEL, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, London, S.W.
1892. ‡Philip, R. W., M.D. 4 Melville-crescent, Edinburgh.
1870. ‡Philip, T. D. 51 South Castle-street, Liverpool.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1853. *Philips, Herbert. The Oak House, Macclesfield.
1877. §Philips, T. Wishart. 3 Tower-villas, George-lane, Woodford, Essex.
1863. ‡Philipson, Dr. 7 Eldon-square, Newcastle-upon-Tyne.
1889. ‡Philipson, John. 9 Victoria-square, Newcastle-upon-Tyne.
1883. ‡Phillips, Arthur G. 20 Canning-street, Liverpool.

Year of
Election.

1894. §Phillips, Staff-Commander E. C. D., R.N., F.R.G.S. 14 Hargreaves-buildings, Chapel-street, Liverpool.
1887. ‡Phillips, H. Harcourt, F.C.S. 183 Moss-lane East, Manchester.
1892. §Phillips, J. H. Poole, Dorset.
1880.§§Phillips, John H., Hon. Sec. Philosophical and Archæological Society, Scarborough.
1890.§§Phillips, R. W., M.A., Professor of Biology in University College, Bangor.
1883. ‡Phillips, S. Rees. Wonford House, Exeter.
1881. ‡Phillips, William. 9 Bootham-terrace, York.
1868. ‡Phipson, T. L., Ph.D., F.C.S. 4 The Cedars, Putney, Surrey, S.W.
1894.§§Pickard-Cambridge, Rev. O., M.A., F.R.S. Bloxworth Rectory, Wareham.
1884. *Pickard, Rev. H. Adair, M.A. 5 Canterbury-road, Oxford.
1883. *Pickard, Joseph William. Oatlands, Lancaster.
1885. *Pickering, Spencer U., M.A., F.R.S., F.C.S. 48 Bryanston-square, London, W.
1884. *Pickett, Thomas E., M.D. Maysville, Mason County, Kentucky, U.S.A.
1888. *Pidgeon, W. R. 42 Porchester-square, London, W.
1871. ‡Pigot, Thomas F., M.R.I.A. Royal College of Science, Dublin.
1884. ‡Pike, L. G., M.A., F.Z.S. 4 The Grove, Highgate, London, N.
1865. ‡Pike, L. Owen. 201 Maida-vale, London, W.
1873. ‡Pike, W. H. University College, Toronto, Canada.
1883. ‡*Pilling, R. C. The Robin's Nest, Blackburn.*
Pim, George, M.R.I.A. Brenanstown, Cabinteely, Co. Dublin.
1877. ‡Pim, Joseph T. Greenbank, Monkstown, Co. Dublin.
1868. ‡Pinder, T. R. St. Andrew's, Norwich.
1876. ‡Pirie, Rev. G., M.A., Professor of Mathematics in the University of Aberdeen. 33 College Bounds, Old Aberdeen.
1884. ‡Pirz, Anthony. Long Island, New York, U.S.A.
1887. ‡Pitkin, James. 56 Red Lion-street, Clerkenwell, London, E.C.
1875. ‡Pitman, John. Redcliff Hill, Bristol.
1883. ‡*Pitt, George Newton, M.A., M.D.* 34 *Ashburn-place, South Kensington, London, S.W.*
1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.
1883. ‡Pitt, Sydney. 16 St. Andrew's-street, Holborn-circus, London, E.C.
1893. *Pitt, Walter, M.Inst.C.E. South Stoke House, near Bath.
1868. ‡Pitt-Rivers, Lieut.-General A. H. L., D.C.L., F.R.S., F.G.S., F.S.A. 4 Grosvenor-gardens, London, S.W.
1842. Playfair, The Right Hon. Lord, G.C.B., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. 68 Onslow-gardens, South Kensington, London, S.W.
1867. ‡Playfair, Lieut.-Colonel Sir R. L., K.C.M.G., H.M. Consul, Algeria. (Messrs. King & Co., Pall Mall, London, S.W.)
1884. *Playfair, W. S., M.D., LL.D., Professor of Midwifery in King's College, London. 31 George-street, Hanover-square, London, W.
1883. *Plimpton, R. T., M.D. 23 Lansdowne-road, Clapham-road, London, S.W.
1893.§§Plowright, Henry J., F.G.S. Brampton Foundries, Chesterfield.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.
1861. *Pochin, Henry Davis, F.C.S. Bodnant Hall, near Conway.
1881. §Pocklington, Henry. 20 Park-row, Leeds.
1888. ‡Pocock, Rev. Francis. 4 Brunswick-place, Bath.
1846. ‡Pole, William, Mus.Doc., F.R.S., M.Inst.C.E. Athenæum Club, Pall Mall, London, S.W.

Year of Election.

*Pollexfen, Rev. John Hutton, M.A. Middleton Tyas Vicarage, Richmond, Yorkshire.
1862. *Polwhele, Thomas Roxburgh, M.A., F.G.S. Polwhele, Truro, Cornwall.
1891. ‡Pomeroy, Captain Ralph. 201 Newport-road, Cardiff.
1892. §§Popplewell, W. C., B.Sc. Claremont-road, Irlams-o'-th'-Height, Manchester.
1868. ‡PORTAL, WYNDHAM S. Malshanger, Basingstoke.
1883. *Porter, Rev. C. T., LL.D. All Saints' Vicarage, Southport.
1883. ‡Postgate, Professor J. P., M.A. Trinity College, Cambridge.
1863. ‡Potter, D. M. Cramlington, near Newcastle-upon-Tyne.
1887. ‡Potter, Edmund P. Hollinhurst, Bolton.
1883. ‡Potter, M. C., M.A., F.L.S., Professor of Botany in the College of Science, Newcastle-upon-Tyne. 14 Portland-terrace, Newcastle-upon-Tyne.
1883. §§Potts, John. Thorn Tree House, Chester-road, Macclesfield.
1886. *POULTON, EDWARD B., M.A., F.R.S., F.L.S., F.G.S., F.Z.S., Professor of Zoology in the University of Oxford. Wykeham House, Oxford.
1873. *Powell, Sir Francis S., Bart., M.P., F.R.G.S. Horton Old Hall, Yorkshire; and 1 Cambridge-square, London, W.
1887. *Powell, Horatio Gibbs. Wood Villa, Tettenhall Wood, Wolverhampton.
1883. ‡Powell, John. Waunarlwydd House, near Swansea.
1894. *Powell, Richard Douglas, M.D. 62 Wimpole-street, London, W.
1875. ‡Powell, William Augustus Frederick. Norland House, Clifton, Bristol.
1887. §Pownall, George H. Manchester and Salford Bank, Mosley-street, Manchester.
1867. ‡Powrie, James. Reswallie, Forfar.
1855. *Poynter, John E. Clyde Neuk, Uddingston, Scotland.
1883. ‡POYNTING, J. H., D.Sc., F.R.S., Professor of Physics in the Mason College, Birmingham. 11 St. Augustine's-road, Birmingham.
1884. ‡Prance, Courtenay C. Hatherley Court, Cheltenham.
1884. *Prankerd, A. A., D.C.L. 27 Norham-road, Oxford.
1891. ‡Pratt, Bickerton. Brynderwen, Maindee, Newport, Monmouthshire.
1869. *PREECE, WILLIAM HENRY, C.B., F.R.S., M.Inst.C.E. Gothic Lodge, Wimbledon Common, Surrey.
1888. *Preece, W. Llewellyn. Telegraph Department, Midland Railway, Derby.
1884. *Premio-Real, His Excellency the Count of. Quebec, Canada.
1894. §Prentice, Manning, F.C.S. Woodfield, Stowmarket.
1892. §Prentice, Thomas. Willow Park, Greenock.
1889. §Preston, Alfred Eley, M.Inst.C.E., F.G.S. 14 The Exchange, Bradford, Yorkshire.
1894. §§Preston, Arthur E. Piccadilly, Abingdon, Berkshire.
1893. *Preston, Martin Inett. 9 St. James's-terrace, Nottingham.
1893. §§PRESTON, Professor THOMAS. 85 Merrion-square, Dublin.
*PRESTWICH, JOSEPH, M.A., D.C.L., F.R.S., F.G.S., F.C.S. Shoreham, near Sevenoaks.
1884. *Prevost, Major L. de T. 2nd Battalion Argyll and Sutherland Highlanders.
1856. *PRICE, Rev. BARTHOLOMEW, M.A., D.D., F.R.S., F.R.A.S., Master of Pembroke College, Oxford.
1882. ‡Price, John E., F.S.A. 27 Bedford-place, Russell-square, London, W.C.

Year of Election.

Price, J. T. Neath Abbey, Glamorganshire.
1888. ‡PRICE, L. L. F. R., M.A., F.S.S. Oriel College, Oxford.
1875. *Price, Rees. 163 Bath-street, Glasgow.
1891. ‡Price, William. 40 Park-place, Cardiff.
1892. ‡Prince, Professor Edward E. Canada.
1875. ‡*Prince, Thomas. 6 Marlborough-road, Bradford, Yorkshire.*
1883. ‡*Prince, Thomas. Horsham-road, Dorking.*
1864. *Prior, R. C. A., M.D. 48 York-terrace, Regent's Park, London, N.W.
1889. *Pritchard, Eric Law, M.D., M.R.C.S. St. Giles, Norwich.
1876. *PRITCHARD, URBAN, M.D., F.R.C.S. 26 Wimpole-street, London, W.
1888. ‡Probyn, Leslie C. Onslow-square, London, S.W.
1881. §Procter, John William. Ashcroft, York.
1863. ‡Proctor, R. S. Grey-street, Newcastle-upon-Tyne.
Proctor, William. Elmhurst, Higher Erith-road, Torquay.
1885. ‡Profeit, Dr. Balmoral, N.B.
1863. ‡*Proud, Joseph. South Hetton, Newcastle-upon-Tyne.*
1884. *Proudfoot, Alexander, M.D. 2 Phillips-place, Montreal, Canada.
1879. *Prouse, Oswald Milton, F.G.S., F.R.G.S. Alvington, Slade-road, Ilfracombe.
1872. *Pryor, M. Robert. Weston, Stevenage, Herts.
1871. *Puckle, Thomas John. 42 Cadogan-place, London, S.W.
1873. ‡Pullan, Lawrence. Bridge of Allan, N.B.
1867. *Pullar, Sir Robert, F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Ochil, Perth.
1891. ‡Pullen, W. W. F. University College, Cardiff.
1842. *Pumphrey, Charles. Southfield, King's Norton, near Birmingham.
1887. §PUMPHREY, WILLIAM. 2 Oakland-road, Redland, Bristol.
1885. §PURDIE, THOMAS, B.Sc., Ph.D., F.R.S., Professor of Chemistry in the University of St. Andrews. 14 South-street, St. Andrews, N.B.
1852. ‡Purdon, Thomas Henry, M.D.Belfast.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1882. ‡Purrott, Charles. West End, near Southampton.
1874. ‡PURSER, FREDERICK, M.A. Rathmines, Dublin.
1866. ‡PURSER, Professor JOHN, M.A., M.R.I.A. Queen's College, Belfast.
1878. ‡Purser, John Mallet. 3 Wilton-terrace, Dublin.
1884. *Purves, W. Laidlaw. 20 Stratford-place, Oxford-street, London, W.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1883. §Pye-Smith, Arnold. 16 Fairfield-road, Croydon.
1883. §Pye-Smith, Mrs. 16 Fairfield-road, Croydon.
1868. ‡PYE-SMITH, P. H., M.D., F.R.S. 48 Brook-street, W.; and Guy's Hospital, London, S.E.
1879. ‡Pye-Smith, R. J. 350 Glossop-road, Sheffield.

1893. §§Quick, James. University College, Bristol.
1894. §§Quick, Professor Walter J. University of Missouri, Columbia, U.S.A.

1870. ‡Rabbits, W. T. 6 Cadogan-gardens, London, S.W.
1887. ‡*Rabone, John. Penderell House, Hamstead-road, Birmingham.*
1870. ‡Radcliffe, D. R. Phœnix Safe Works, Windsor, Liverpool.
1877. ‡Radford, George D. Mannamead, Plymouth.
1879. ‡*Radford, R. Heber. Wood Bank, Pitsmoor, Sheffield.*
*Radford, William, M.D. Sidmount, Sidmouth.

Year of Election.

1855. *Radstock, The Right Hon. Lord. Mayfield, Woolston, Southampton.
1888. ‡Radway, C. W. 9 Bath-street, Bath.
1887. *Ragdale, John Rowland. The Beeches, Whitefield, Manchester.
1864. ‡Rainey, James T. 3 Kent-gardens, Ealing, London, W.
Rake, Joseph. Charlotte-street, Bristol.
1894. *RAMBAUT, ARTHUR A., M.A., D.Sc., F.R.A.S., M.R.I.A., Andrews' Professor of Astronomy in the University of Dublin, and Astronomer Royal for Ireland. Dunsink Observatory, Co. Dublin.
1885. ‡Ramsay, Major. Straloch, N.B.
1863. ‡RAMSAY, ALEXANDER, F.G.S. 2 Cowper-road, Acton, Middlesex, W.
1884. ‡Ramsay, George G., LL.D., Professor of Humanity in the University of Glasgow. 6 The College, Glasgow.
1884. ‡Ramsay, Mrs. G. G. 6 The College, Glasgow.
1861. ‡Ramsay, John. Kildalton, Argyllshire.
1889. ‡Ramsay, Major R. G. W. Bonnyrigg, Edinburgh.
1867. **Ramsay, W. F., M.D. 109 Sinclair-road, West Kensington Park, London, W.*
1876. *RAMSAY, WILLIAM, Ph.D., F.R.S., F.C.S., Professor of Chemistry in University College, London, W.C.
1883. ‡Ramsay, Mrs. 12 Arundel-gardens, London, W.
1887. ‡Ramsbottom, John. Fernhill, Alderley Edge, Cheshire.
1835. *Rance, Henry. 6 Ormond-terrace, Regent's Park, London, N.W.
1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, West Kensington, London, W.
1868. *Ransom, Edwin, F.R.G.S. Ashburnham-road, Bedford.
1893. ‡Ransom, W. B., M.D. The Pavement, Nottingham.
1863. ‡RANSOM, WILLIAM HENRY, M.D., F.R.S. The Pavement, Nottingham.
1861. ‡RANSOME, ARTHUR, M.A., M.D., F.R.S. Devisdale, Bowdon, Manchester.
Ransome, Thomas. Hest Bank, near Lancaster.
1889. §Rapkin, J. B. Sidcup, Kent.
Rashleigh, Jonathan. 3 Cumberland-terrace, Regent's Park, London, N.W.
1864. ‡Rate, Rev. John, M.A. Fairfield, East Twickenham.
1892. §Rathbone, Miss May. Backwood, Neston, Cheshire.
1870. ‡Rathbone, Philip H. Greenbank Cottage, Wavertree, Liverpool.
1870. §Rathbone, R. R. Glan y Menai, Anglesey.
1895. §§RATHBONE, W. Green Bank, Liverpool.
1874. ‡RAVENSTEIN, E. G., F.R.G.S., F.S.S. Albion House, 91 Upper Tulse-hill, London, S.W.
Rawdon, William Frederick, M.D. Bootham, York.
1889. ‡Rawlings, Edward. Richmond House, Wimbledon Common, Surrey.
1870. ‡Rawlins, G. W. The Hollies, Rainhill, Liverpool.
1866. *RAWLINSON, Rev. Canon GEORGE, M.A. The Oaks, Precincts, Canterbury.
1887. ‡Rawson, Harry. Earlswood, Ellesmere Park, Eccles, Manchester.
1875. §§RAWSON, Sir RAWSON W., K.C.M.G., C.B., F.R.G.S. 68 Cornwall-gardens, Queen's-gate, London, S.W.
1886. ‡Rawson, W. Stepney, M.A., F.C.S. 68 Cornwall-gardens, Queen's-gate, London, S.W.
1868. *RAYLEIGH, The Right Hon. Lord, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S., F.R.G.S., Professor of Natural Philosophy in the Royal Institution, London. Terling Place, Witham, Essex.
1895. §Raynbird, Hugh, jun. Garrison Gateway Cottage, Old Basing, Basingstoke.
1883. *Rayne, Charles A., M.D., M.R.C.S. Queen-street, Lancaster.

Year of Election.

*Read, W. H. Rudston, M.A. 12 Blake-street, York.
1870. ‡READE, THOMAS MELLARD, F.G.S. Blundellsands, Liverpool.
1884. §Readman, J. B., D.Sc., F.R.S.E. 4 Lindsay-place, Edinburgh.
1852. *REDFERN, Professor PETER, M.D. 4 Lower-crescent, Belfast.
1892. ‡Redgrave, Gilbert R., Assoc.M.Inst.C.E. Grove Lodge, Muswell Hill, London, N.
1863. ‡Redmayne, Giles. 20 New Bond-street, London, W.
1889. ‡Redmayne, J. M. Harewood, Gateshead.
1889. ‡Redmayne, Norman. 26 Grey-street, Newcastle-upon-Tyne.
1888. ‡Rednall, Miss Edith E. Ashfield House, Neston, near Chester.
1890. *Redwood, Boverton, F.R.S.E., F.C.S. 4 Bishopsgate-street Within, London E.C.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1891. ‡Reece, Lewis Thomas. Somerset House, Roath, Cardiff.
1861. ‡REED, Sir EDWARD JAMES, K.C.B., F.R.S. 75 Harrington-gardens, London, S.W.
1889. ‡Reed, Rev. George. Bellingham Vicarage, Bardon Mill, Carlisle.
1891. *Reed, Thomas A. Bute Docks, Cardiff.
1894. *Rees, Edmund S. G., 15 Merridale-lane, Wolverhampton.
1891. §Rees, I. Treharne, M.Inst.C.E. The Elms, Penarth.
1891. ‡Rees, Samuel. West Wharf, Cardiff.
1891. ‡Rees, William. 25 Park-place, Cardiff.
1888. ‡Rees, W. L. 11 North-crescent, Bedford-square, London, W.C.
1875. ‡Rees-Mogg, W. Wooldridge. Cholwell House, near Bristol.
1881. §Reid, Arthur S., B.A., F.G.S. Trinity College, Glenalmond, N.B.
1883. *REID, CLEMENT, F.L.S., F.G.S. 28 Jermyn-street, London, S.W.
1892. §§Reid, E. Waymouth, B.A., Professor of Physiology in University College, Dundee.
1889. ‡Reid, George, Belgian Consul. Leazes House, Newcastle-upon-Tyne.
1876. ‡Reid, James. 10 Woodside-terrace, Glasgow.
1884. ‡*Reid, Rev. James, B.A. Bay City, Michigan, U.S.A.*
1892. §§Reid, Thomas. University College, Dundee.
1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.
1850. ‡Reid, William, M.D. Cruivie, Cupar, Fife.
1893. §Reinach, Baron Albert von. Frankfort s. M., Prussia.
1875. §REINOLD, A. W., M.A., F.R.S., Professor of Physics in the Royal Naval College, Greenwich, S.E.
1863. ‡RENALS, E. 'Nottingham Express' Office, Nottingham.
1894. §RENDALL, G. H., M.A., Principal of University College, Liverpool.
1891. §Rendell, Rev. J. R. Whinside, Whalley-road, Accrington.
1885. ‡Rennett, Dr. 12 Golden-square, Aberdeen.
1889. *Rennie, George B. Hooley Lodge, Redhill.
1867. ‡Renny, W. W. 8 Douglas-terrace, Broughty Ferry, Dundee.
1883. *Reynolds, A. H. Manchester and Salford Bank, Southport.
1871. ‡REYNOLDS, JAMES EMERSON, M.D., D.Sc., F.R.S., F.C.S., M.R.I.A., Professor of Chemistry in the University of Dublin. The Laboratory, Trinity College, Dublin.
1870. *REYNOLDS, OSBORNE, M.A., LL.D., F.R.S., M.Inst.C.E., Professor of Engineering in Owens College, Manchester. 23 Lady Barn-road, Fallowfield, Manchester.
1858. §REYNOLDS, RICHARD, F.C.S. 13 Briggate, and Cliff Lodge, Hyde Park, Leeds.
1887. ‡Rhodes, George W. The Cottage, Victoria Park, Manchester.
1883. ‡Rhodes, Dr. James. 25 Victoria-street, Glossop.
1890. ‡Rhodes, J. M., M.D. Ivy Lodge, Didsbury.
1858. *Rhodes, John. Potternewton House, Leeds.

Year of Election.

1877. *Rhodes, John. 360 Blackburn-road, Accrington, Lancashire.
1888.§§Rhodes, John George. Warwick House, 46 St. George's-road, London, S.W.
1884. ‡Rhodes, Lieut.-Colonel William. Quebec, Canada.
1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Rua Muro, 14, Modena, Italy.
1891. ‡Richards, D. 1 St. Andrew's-crescent, Cardiff.
1891. ‡Richards, H. M. 1 St. Andrew's-crescent, Cardiff.
1889. ‡Richards, Professor T. W., Ph.D. Cambridge, Massachusetts, U.S.A.
1888. *RICHARDSON, ARTHUR, M.D. University College, Bristol.
1863. ‡RICHARDSON, Sir BENJAMIN WARD, M.A., M.D., LL.D., F.R.S. 25 Manchester-square, London, W.
1861. ‡Richardson, Charles. 10 Berkeley-square, Bristol.
1869. *Richardson, Charles. 15 Burnaby-gardens, Chiswick, London, W.
1882. §Richardson, Rev. George, M.A. The College, Winchester.
1884. *Richardson, George Straker. Isthmian Club, 150 Piccadilly, London, W.
1889. §Richardson, Hugh. Sedbergh School, Sedbergh R.S.O., Yorkshire.
1884. *Richardson, J. Clarke. Derwen Fawr, Swansea.
1870. ‡Richardson, Ralph, F.R.S.E. 10 Magdala-place, Edinburgh.
1889. ‡Richardson, Thomas, J.P. 7 Windsor-terrace, Newcastle-upon-Tyne.
1881. ‡Richardson, W. B. Elm Bank, York.
1876. §Richardson, William Haden. City Glass Works, Glasgow.
1891. ‡Riches, Carlton H. 21 Dumfries-place, Cardiff.
1891. §Riches, T. Harry. 8 Park-grove, Cardiff.
1886. §Richmond, Robert. Leighton Buzzard.
1868. ‡RICKETTS, CHARLES, M.D., F.G.S. 19 Hamilton-square, Birkenhead.
1877. ‡*Ricketts, James, M.D. St. Helens, Lancashire.*
*RIDDELL, Major-General CHARLES J. BUCHANAN, C.B., R.A., F.R.S. Oaklands, Chudleigh, Devon.
1883. *RIDEAL, SAMUEL, D.Sc., F.C.S. 28 Victoria-mansions, London, S.W.
1862. ‡*Ridgway, Henry Ackroyd, B.A. Bank Field, Halifax.*
1894. §RIDLEY, E. P. 6 Paget-road, Ipswich.
1861. ‡Ridley, John. 19 Belsize-park, Hampstead, London, N.W.
1889. ‡Ridley, Thomas D. Coatham, Redcar.
1884. ‡Ridout, Thomas. Ottawa, Canada.
1881. *Rigg, Arthur. 5 Harewood-square, London, N.W.
1883. *RIGG, EDWARD, M.A. Royal Mint, London, E.
1883. ‡*Rigg, F. F., M.A. 32 Queen's-road, Southport.*
1892. ‡Rintoul, D., M.A. Clifton College, Bristol.
1873. ‡Ripley, Sir Edward, Bart. Acacia, Apperley, near Leeds.
*RIPON, The Most Hon. the Marquess of, K.G., G.C.S.I., C.I.E., D.C.L., F.R.S., F.L.S., F.R.G.S. 9 Chelsea Embankment, London, S.W.
1892. ‡Ritchie, R. Peel, M.D., F.R.S.E. 1 Melville-crescent, Edinburgh.
1867. ‡Ritchie, William. Emslea, Dundee.
1889. ‡Ritson, U. A. 1 Jesmond-gardens, Newcastle-upon-Tyne.
1869. *Rivington, John. Babbicombe, near Torquay.
1888. ‡Robb, W. J. Firth College, Sheffield.
1869. *ROBBINS, JOHN, F.C.S. 57 Warrington-crescent, Maida Vale, London, W.
1878. ‡Roberts, Charles, F.R.C.S. 2 Bolton-row, London, W.
1887. *Roberts, Evan. Thorncliffe, 5 York-road, Southport.
1859. ‡Roberts, George Christopher. Hull.

Year of Election.

1870. *ROBERTS, ISAAC, D.Sc., F.R.S., F.R.A.S., F.G.S. Starfield, Crowborough, Sussex.
1894. *Roberts, Miss Janora. 5 York-road, Birkdale, Southport.
1891. ‡*Roberts, Rev. John Crossby, F.R.G.S. 41 Derby-road, East Park, Northampton.*
1881. ‡Roberts, R. D., M.A., D.Sc., F.G.S. 17 Charterhouse-square, London, E.C.
1879. ‡Roberts, Samuel. The Towers, Sheffield.
1879. ‡Roberts, Samuel, jun. The Towers, Sheffield.
1883. ‡ROBERTS, Sir WILLIAM, M.D., F.R.S. 8 Manchester-square, London, W.
1868. *ROBERTS-AUSTEN, W. CHANDLER, C.B., F.R.S., F.C.S., Chemist to the Royal Mint, and Professor of Metallurgy in the Royal College of Science, London. Royal Mint, London, E.
1883. ‡Robertson, Alexander. Montreal, Canada.
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1884. ‡Robertson, E. Stanley, M.A. 43 Waterloo-road, Dublin.
1871. ‡Robertson, George, M.Inst.C.E., F.R.S.E. Athenæum Club, London, S.W.
1883. ‡Robertson, George H. Plas Newydd, Llangollen.
1883. ‡Robertson, Mrs. George H. Plas Newydd, Llangollen.
1876. ‡*Robertson, R. A. Newthorn, Ayton-road, Pollokshields, Glasgow.*
1892. ‡Robertson, W. W. 3 Parliament-square, Edinburgh.
1888. *Robins, Edward Cookworthy, F.S.A. 8 Marlborough-road, St. John's Wood, London, N.W.
1886. *Robinson, C. R. 27 Elvetham-road, Birmingham.
1886. ‡*Robinson, Edward E. 56 Dovey-street, Liverpool.*
1861. ‡Robinson, Enoch. Dukinfield, Ashton-under-Lyne.
1887. ‡Robinson, Henry. 7 Westminster-chambers, London, S.W.
1861. ‡*Robinson, John, M.Inst.C.E. Atlas Works, Manchester.*
1888. ‡Robinson, John. Engineer's Office, Barry Dock, Cardiff.
1863. ‡Robinson, J. H. 6 Montallo-terrace, Barnard Castle.
1878. ‡Robinson, John L. 198 Great Brunswick-street, Dublin.
1895. *Robinson, Joseph Johnson. 8 Trafalgar-road, Birkdale, Southport.
1876. ‡Robinson, M. E. 6 Park-circus, Glasgow.
1887. §Robinson, Richard. Bellfield Mill, Rochdale.
1881. ‡Robinson, Richard Atkinson. 195 Brompton-road, London, S.W.
1875. *Robinson, Robert, M.Inst.C.E., F.G.S. Beechwood, Darlington.
1884. ‡Robinson, Stillman. Columbus, Ohio, U.S.A.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1891. ‡Robinson, William, Assoc.M.Inst.C.E., Professor of Engineering in University College, Nottingham.
1888. ‡Robottom, Arthur. 3 St. Alban's-villas, Highgate-road, London, N.W.
1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster, S.W.
1876. ‡*Robson, Hazleton R. 14 Royal-crescent West, Glasgow.*
1872. *Robson, William. 5 Gillsland-road, Merchiston, Edinburgh.
1885. *Rodger, Edward. 1 Clairmont-gardens, Glasgow.
1894. *Rodger, J. W. 80 Anerley-park, London, S.E.
1885. *Rodriguez, Epifanio. 12 John-street, Adelphi, London, W.C.
1866. ‡Roe, Sir Thomas, M.P. Grove-villas, Litchurch.
1867. ‡Rogers, James S. Rosemill, by Dundee.
1890. *Rogers, L. J., M.A., Professor of Mathematics in Yorkshire College, Leeds. 13 Beech Grove-terrace, Leeds.
1883. ‡Rogers, Major R. Alma House, Cheltenham.
1882. §Rogers, Rev. Saltren, M.A. Gwennap, Redruth, Cornwall.
1884. *Rogers, Walter M. Lamowa, Falmouth.

Year of Election.

1889. ‡Rogerson, John. Croxdale Hall, Durham.
1876. ‡Rollit, Sir A. K., M.P., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. Thwaite House, Cottingham, East Yorkshire.
1892. *Romanes, John. 3 Oswald-road, Edinburgh.
1891. ‡Rönnfeldt, W. 43 Park-place, Cardiff.
1894. *Rooper, T. Godolphin. The Elms, High Harrogate.
1869. ‡Roper, C. H. Magdalen-street, Exeter.
1872. *Roper, Freeman Clarke Samuel, F.L.S., F.G.S. Palgrave House, Eastbourne.
1881. *Roper, W. O. Bank Buildings, Lancaster.
1855. *Roscoe, Sir Henry Enfield, B.A., Ph.D., LL.D., D.C.L., F.R.S. 10 Bramham-gardens, London, S.W.
1883. *Rose, J. Holland, M.A. 11 Endlesham-road, Balham, London, S.W.
1892. ‡Rose, Hugh. Kilravock Lodge, Blackford-avenue, Edinburgh.
1894. §Rose, T. K. 9 Royal Mint, London, E.
1885. ‡Ross, Alexander. Riverfield, Inverness.
1874. ‡Ross, Alexander Milton, M.A., M.D., F.G.S. Toronto, Canada.
1887. ‡Ross, Edward. Marple, Cheshire.
1880. ‡Ross, Captain G. E. A., F.G.S. 8 Collingham-gardens, Cromwell-road, London, S.W.
1859. *Ross, Rev. James Coulman. Wadworth Hall, Doncaster.
1869. *Rosse, The Right Hon. the Earl of, K.P., B.A., D.C.L., LL.D., F.R.S., F.R.A.S., M.R.I.A. Birr Castle, Parsonstown, Ireland.
1891. §Roth, H. Ling. 32 Prescott-street, Halifax, Yorkshire.
1893. ‡Rothera, G. B. Sherwood Rise, Nottingham.
1865. *Rothera, George Bell, F.L.S. Orston House, Sherwood Rise, Nottingham.
1876. ‡Rottenburgh, Paul. 13 Albion-crescent, Glasgow.
1884. *Rouse, M. L. 54 Westbourne-villas, West Brighton.
1861. ‡Routh, Edward J., M.A., D.Sc., F.R.S., F.R.A.S., F.G.S. St. Peter's College, Cambridge.
1861. ‡Rowan, David. Elliot-street, Glasgow.
1883. ‡Rowan, Frederick John. 134 St. Vincent-street, Glasgow.
1887. ‡Rowe, Rev. Alfred W., M.A. Felstead, Essex.
1881. ‡Rowe, Rev. G. Lord Mayor's Walk, York.
1865. ‡Rowe, Rev. John. 13 Hampton-road, Forest Gate, Essex.
1877. ‡Rowe, J. Brooking, F.L.S., F.S.A. 16 Lockyer-street, Plymouth.
1890. ‡Rowley, Walter, F.S.A. Alderhill, Meanwood, Leeds.
1881. *Rowntree, Joseph. 38 St. Mary's, York.
1881. *Rowntree, J. S. Mount Villas, York.
1876. ‡Roxburgh, John. 7 Royal Bank-terrace, Glasgow.
1883. ‡Roy, Charles S., M.D., F.R.S., Professor of Pathology in the University of Cambridge. Trinity College, Cambridge.
1885. ‡Roy, John. 33 Belvidere-street, Aberdeen.
1888. ‡Roy, Parbati Churn, B.A. Calcutta, Bengal, India.
1875. *Rücker, A. W., M.A., D.Sc., F.R.S., Professor of Physics in the Royal College of Science, London. (General Treasurer.) 19 Gledhow-gardens, South Kensington, London, S.W.
1892. §Rücker, Mrs. Levetleigh, Dane-road, St. Leonard's-on-Sea.
1869. §Rudler, F. W., F.G.S. The Museum, Jermyn-street, London, S.W.
1882. ‡Rumball, Thomas, M.Inst.C.E. 8 Queen Anne's-gate, London, S.W.
1884. ‡*Runtz, John. Linton Lodge, Lordship-road, Stoke Newington, London, N.*
1887. §Ruscoe, John, F.R.G.S., F.G.S. Ferndale, Gee Cross, near Manchester.

Year of Election.

1847. ‡RUSKIN, JOHN, M.A., D.C.L., F.G.S. Brantwood, Coniston, Ambleside.
1889. ‡Russell, The Right Hon. Earl. Amberley Cottage, Maidenhead.
1875. *Russell, The Hon. F. A. R. Pembroke Lodge, Richmond Park, Surrey.
1884. ‡Russell, George. 13 Church-road, Upper Norwood, London, S.E.
1890. ‡Russell, J. A., M.B. Woodville, Canaan-lane, Edinburgh.
1883. *Russell, J. W. 16 Bardwell-road, Oxford.
Russell, John. 39 Mountjoy-square, Dublin.
1852. *Russell, Norman Scott. Arts Club, Hanover-square, London, W.
1876. ‡Russell, Robert, F.G.S. 1 Sea View, St. Bees, Carnforth.
1886. ‡Russell, Thomas H. 3 Newhall-street, Birmingham.
1852. *RUSSELL, WILLIAM J., Ph.D., F.R.S., F.C.S., Lecturer on Chemistry in St. Bartholomew's Medical College. 34 Upper Hamilton-terrace, St. John's Wood, London, N.W.
1886. ‡Rust, Arthur. Eversleigh, Leicester.
1883. *Ruston, Joseph. Monk's Manor, Lincoln.
1891. §Rutherford, George. Garth House, Taff's Well, Cardiff.
1871. §RUTHERFORD, WILLIAM, M.D., F.R.S., F.R.S.E., Professor of Physiology in the University of Edinburgh.
1887. ‡Rutherford, William. 7 Vine-grove, Chapman-street, Hulme, Manchester.
Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1879. ‡Ruxton, Vice-Admiral Fitzherbert, R.N., F.R.G.S. 41 Cromwell-gardens, London, S.W.
1875. ‡Ryalls, Charles Wager, LL.D. 3 Brick-court, Temple, London, E.C.
1889. ‡Ryder, W. J. H. 52 Jesmond-road, Newcastle-upon-Tyne.
1865. ‡Ryland, Thomas. The Redlands, Erdington, Birmingham.
1861. *RYLANDS, THOMAS GLAZEBROOK, F.L.S., F.G.S. Highfields, Thelwall, near Warrington.

1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. 186 Aldersgate-street, London, E.C.
1885. ‡Saint, W. Johnston. 11 Queen's-road, Aberdeen.
1866. *ST. ALBANS, His Grace the Duke of. Bestwood Lodge, Arnold, near Nottingham.
1886. §St. Clair, George, F.G.S. 225 Castle-road, Cardiff.
1893. §§SALISBURY, The Most Hon. the Marquis of, K.G., D.C.L., F.R.S. 20 Arlington Street, London, S.W.
1881. ‡Salkeld, William. 4 Paradise-terrace, Darlington.
1857. ‡SALMON, Rev. GEORGE, D.D., D.C.L., LL.D., F.R.S., Provost of Trinity College, Dublin.
1883. ‡Salmond, Robert G. Kingswood-road, Upper Norwood, S.E.
1873. *Salomons, Sir David, Bart., F.G.S. Broomhill, Tunbridge Wells.
1872. ‡SALVIN, OSBERT, M.A., F.R.S., F.L.S. Hawksfold, Haslemere.
1887. ‡Samson, C. L. Carmona, Kersal, Manchester.
1861. *Samson, Henry. 6 St. Peter's-square, Manchester.
1894. §SAMUELSON, The Right Hon. Sir BERNHARD, Bart., F.R.S., M.Inst.C.E. 56 Prince's-gate, London, S.W.
1878. ‡Sanders, Alfred, F.L.S. 2 Clarence-place, Gravesend, Kent.
1883. *Sanders, Charles J. B. Pennsylvania, Exeter.
1884. ‡Sanders, Henry. 185 James-street, Montreal, Canada.
1883. ‡Sanderson, Deputy Surgeon-General Alfred. East India United Service Club, St. James's-square, London, S.W.
1872. §SANDERSON, J. S. BURDON, M.A., M.D., D.Sc., LL.D., D.C.L., F.R.S., F.R.S.E., Regius Professor of Medicine in the University of Oxford. 64 Banbury-road, Oxford.

Year of Election.

1883. ‡Sanderson, Mrs. Burdon. 64 Banbury-road, Oxford.
1893. ‡Sanderson, Oundle. 9 The Ropewalk, Nottingham.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1892. §Sang, William D. 28 Whyte's Causeway, Kirkcaldy, Fife.
1886. §Sankey, Percy E. Down Lodge, Fairlight, Hastings.
1886. ‡Sauborn, John Wentworth. Albion, New York, U.S.A.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1868. ‡Saunders, A., M.Inst.C.E. King's Lynn.
1886. ‡Saunders, C. T. Temple-row, Birmingham.
1881. ‡SAUNDERS, HOWARD, F.L.S., F.Z.S. 7 Radnor-place, London, W.
1883. ‡Saunders, Rev. J. C. Cambridge.
1846. ‡SAUNDERS, TRELAWNEY W., F.R.G.S. 3 Elmfield on the Knowles, Newton Abbot, Devon.
1884. ‡Saunders, William. Experimental Farm, Ottawa, Canada.
1891. ‡Saunders, W. H. R. Llanishen, Cardiff.
1884. ‡Saunderson, C. E. 26 St. Famille-street, Montreal, Canada.
1887. §Savage, Rev. E. B., M.A., F.S.A. St. Thomas' Parsonage, Douglas, Isle of Man.
1871. ‡Savage, W. D. Ellerslie House, Brighton.
1883. ‡Savage, W. W. 109 St. James's-street, Brighton.
1883. ‡Savery, G. M., M.A. The College, Harrogate.
1872. *Sawyer, George David. 55 Buckingham-place, Brighton.
1887. §SAYCE, Rev. A. H., M.A., D.D. Queen's College, Oxford.
1884. ‡Sayre, Robert H. Bethlehem, Pennsylvania, U.S.A.
1883. *Scarborough, George. Whinney Field, Halifax, Yorkshire.
1884. ‡Scarth, William Bain. Winnipeg, Manitoba, Canada.
1879. *SCHÄFER, E. A., F.R.S., M.R.C.S., Professor of Physiology in University College, London. (GENERAL SECRETARY.) Croxley Green, Rickmansworth.
1883. ‡Schäfer, Mrs. Croxley Green, Rickmansworth.
1888. §SCHARFF, ROBERT F., Ph.D., B.Sc., Keeper of the Natural History Department, Museum of Science and Art, Dublin.
1880. *Schemmann, Louis Carl. Hamburg. (Care of Messrs. Allen Everitt & Sons, Birmingham.)
1892. ‡Schloss, David F. 1 Knaresborough-place, London, S.W.
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1887. ‡Schofield, T. Thornfield, Talbot-road, Old Trafford, Manchester.
1883. ‡Schofield, William. Alma-road, Birkdale, Southport.
1885. §§Scholes, L. Eden-terrace, Harriet-street, Stretford, near Manchester.
SCHUNCK, EDWARD, Ph.D., F.R.S., F.C.S. Oaklands, Kersal Moor, Manchester.
1873. *SCHUSTER, ARTHUR, Ph.D., F.R.S., F.R.A.S., Professor of Physics in the Owens College, Manchester.
1887. ‡Schwabe, Colonel G. Salis. Portland House, Higher Crumpsall, Manchester.
1847. *SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., Sec.Z.S. 3 Hanover-square, London, W.
1883. *SCLATER, WILLIAM LUTLEY, M.A., F.Z.S. Eton College, Windsor.
1867. ‡SCOTT, ALEXANDER. Clydesdale Bank, Dundee.
1881. *Scott, Alexander, M.A., D.Sc. University Chemical Laboratory, Cambridge.
1882. ‡Scott, Colonel A. de C., R.E. Ordnance Survey Office, Southampton.
1878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.
1881. §§Scott, Miss Charlotte Angas, D.Sc. Lancashire College, Whalley Range, Manchester.

Year of Election.

1889. §SCOTT, D. H., M.A., Ph.D., F.R.S., F.L.S. The Old Palace, Richmond, Surrey.
1885. ‡Scott, George Jamieson. Bayview House, Aberdeen.
1886. ‡*Scott, Robert. 161 Queen Victoria-street, London, E.C.*
1857. *SCOTT, ROBERT H., M.A., F.R.S., F.G.S., F.R.Met.S., Secretary to the Council of the Meteorological Office. 6 Elm Park-gardens, London, S.W.
1884. *Scott, Sydney C. 28 The Avenue, Gipsy Hill, S.E.
1869. ‡Scott, William Bower. Chudleigh, Devon.
1895. §Scott-Elliott, G. F. Newton, Dumfries.
1881. *Scrivener, A. P. Haglis House, Wendover.
1883. ‡Scrivener, Mrs. Haglis House, Wendover.
1895. §Scull, Miss E. M. L. 2 Langland-gardens, Finchley-road, London, N.W.
1890. §§Searle, G. F. C., B.A. Peterhouse, Cambridge.
1859. ‡Seaton, John Love. The Park, Hull.
1880 ‡SEDGWICK, ADAM, M.A., F.R.S. Trinity College, Cambridge.
1880. ‡SEEBOHM, HENRY, F.R.G.S., F.L.S., F.Z.S. 22 Courtfield-gardens, London, S.W.
1861. *SEELEY, HARRY GOVIER, F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S., Professor of Geography in King's College, London. 25 Palace Gardens-terrace, Kensington, London, W.
1895. §§SEFTON, The Right Hon. the Earl of. Abbeystead, Lancaster.
1893. ‡SELBY-BIGGE, L. A., M.A. University College, Oxford.
1891. ‡Selby, Arthur L., M.A., Assistant Professor of Physics in University College, Cardiff.
1855. ‡Seligman, H. L. 27 St. Vincent-place, Glasgow.
1879. ‡Selim, Adolphus. 21 Mincing-lane, London, E.C.
1885. ‡Semple, Dr. A. United Service Club, Edinburgh.
1887. §Semple, James C., F.R.G.S., M.R.I.A. 2 Marine-terrace, Kingstown, Co. Dublin.
1873. ‡Semple, R. H., M.D. 8 Torrington-square, London, W.C.
1892. ‡Semple, William. Gordon's College, Aberdeen.
1888. *SENIER, ALFRED, M.D., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
1858. *Senior, George. Old Whittington, Chesterfield.
1888. *Sennett, Alfred R., A.M.Inst.C.E. 39 Bedford Place, Bloomsbury-square, W.C.
1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.
1892. §§Seton, Miss Jane. 37 Candlemaker-row, Edinburgh.
1895. §Seton-Karr, H. W. Wimbledon, Surrey.
1875. ‡*Seville, Thomas. Blythe House, Southport.*
1892. ‡Seward, A. C., M.A., F.G.S. 33 Chesterton-road, Cambridge.
1891. ‡Seward, Edwin. 55 Newport-road, Cardiff.
1868. ‡Sewell, Philip E. Catton, Norwich.
1891. ‡Shackell, E. W. 191 Newport-road, Cardiff.
1888. ‡Shackles, Charles F. Hornsea, near Hull.
1883. ‡Shadwell, John Lancelot. 30 St. Charles-square, Ladbroke Grove-road, London, W.
1871. *Shand, James. Parkholme, Elm Park-gardens, London, S.W.
1867. ‡Shanks, James. Dens Iron Works, Arbroath, N.B.
1881. ‡Shann, George, M.D. Petergate, York.
1869. *Shapter, Dr. Lewis, LL.D. 1 Barnfield-crescent, Exeter.
1878. ‡SHARP, DAVID, M.A., M.B., F.R.S., F.L.S. Museum of Zoology, Cambridge.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1886. ‡Sharp, T. B. French Walls, Birmingham.

Year of Election.

*SHARP, WILLIAM, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
1883. ‡Sharples, Charles H., F.C.S. 7 Fishergate, Preston.
1870. ‡Shaw, Duncan. Cordova, Spain.
1865. ‡Shaw, George. Cannon-street, Birmingham.
1887. *Shaw, James B. Holly Bank, Cornbrook, Manchester.
1870. ‡Shaw, John. 21 St. James's-road, Liverpool.
1891. ‡Shaw, Joseph. 1 Temple-gardens, London, E.C.
1889. *Shaw, Mrs. M. S., B.Sc. Halberton, near Tiverton, Devon.
1887. §§Shaw, Saville, F.C.S. College of Science, Newcastle-upon-Tyne.
1883. *SHAW, W. N., M.A., F.R.S. Emmanuel House, Cambridge.
1883. ‡Shaw, Mrs. W. N. Emmanuel House, Cambridge.
1891. ‡Sheen, Dr. Alfred. 23 Newport-road, Cardiff.
1884. ‡Sheldon, Professor J. P. Downton College, near Salisbury.
1878. ‡Shelford, William, M.Inst.C.E. 35A Great George-street, Westminster, S.W.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1881. ‡SHENSTONE, W. A. Clifton College, Bristol.
1885. ‡Shepherd, Rev. Alexander. Ecclesmechen, Uphall, Edinburgh.
1885. ‡Shepherd, Charles. 1 Wellington-street, Aberdeen.
1890. ‡Shepherd, J. Care of J. Redmayne, Esq., Grove House, Headingley, Leeds.
1883. ‡Shepherd, James. Birkdale, Southport.
1883. ‡Sherlock, David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Mrs. David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Rev. Edgar. Bentham Rectory, *viâ* Lancaster.
1888. *Shickle, Rev. C. W., M.A. Langridge Rectory, Bath.
1886. ‡Shield, Arthur H. 35A Great George-street, London, S.W.
1892. ‡Shields, John, D.Sc., Ph.D. Dolphingston, Tranent, Scotland.
1883. *Shillitoe, Buxton, F.R.C.S. 2 Frederick-place, Old Jewry, London, E.C.
1867. ‡Shinn, William C. 39 Varden's-road, Clapham Junction, Surrey, S.W.
1887. *SHIPLEY, ARTHUR E., M.A. Christ's College, Cambridge.
1889. ‡Shipley, J. A. D. Saltwell Park, Gateshead.
1885. ‡Shirras, G. F. 16 Carden-place, Aberdeen.
1883. ‡Shone, Isaac. Pentrefelin House, Wrexham.
1870. *SHOOLBRED, JAMES N., M.Inst.C.E., F.G.S. 47 Victoria-street, London, S.W.
1888. ‡Shoppee, C. H. 22 John-street, Bedford-row, London, W.C.
1888. §Shoppee, G. A., M.A., LL.D. 7 Furnival's Inn, London, E.C.
1875. ‡SHORE, THOMAS W., F.G.S. Hartley Institution, Southampton.
1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital, E.C.
1889. ‡Sibley, Walter K., B.A., M.B. 7 Upper Brook-street, London, W.
1883. ‡Sibly, Miss Martha Agnes. Flook House, Taunton.
1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.
1883. *Sidebotham, James Nasmyth. Parkfield, Altrincham, Cheshire.
1877. *Sidebotham, Joseph Watson, M.P. Erlesdene, Bowdon, Cheshire.
1885. *SIDGWICK, HENRY, M.A., Litt.D., D.C.L., Professor of Moral Philosophy in the University of Cambridge. Hillside, Chesterton-road, Cambridge.
Sidney, M. J. F. Cowpen, Newcastle-upon-Tyne.
1873. *Siemens, Alexander. 7 Airlie-gardens, Campden Hill, London, W.
1878. ‡SIGERSON, Professor GEORGE, M.D., F.L.S., M.R.I.A. 3 Clare-street, Dublin.
1859. ‡Sim, John. Hardgate, Aberdeen.

Year of Election.

1871. ‡Sime, James. Craigmount House, Grange, Edinburgh.
1862. ‡Simms, James. 138 Fleet-street, London, E.C.
1874. ‡Simms, William. Upper Queen-street, Belfast.
1876. ‡Simon, Frederick. 24 Sutherland-gardens, London, W.
1887. *Simon, Henry. Lawnhurst, Didsbury, near Manchester.
1847. ‡SIMON, Sir JOHN, K.C.B., D.C.L., F.R.S., F.R.C.S., Consulting Surgeon to St. Thomas's Hospital. 40 Kensington-square, London, W.
1866. ‡Simons, George. The Park, Nottingnam.
1893. ‡Simpson, A. H., F.R.Met.Soc. Attenborough, Nottinghamshire.
1871. *SIMPSON, ALEXANDER R., M.D., Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.
1883. ‡Simpson, Byron R. 7 York-road, Birkdale, Southport.
1887. ‡Simpson, F. Estacion Central, Buenos Ayres.
1859. ‡Simpson, John. Maykirk, Kincardineshire.
1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1857. ‡SIMPSON, MAXWELL, M.D., LL.D., F.R.S., F.C.S., 9 Barton-street, West Kensington, London, W.
1894. §Simpson, Thomas. Fennymere, Castle Bar, Ealing, London, W.
1883. ‡Simpson, Walter M. 7 York-road, Birkdale, Southport.
Simpson, William. Bradmore House, Hammersmith, London, W.
1887. ‡Sinclair, Dr. 268 Oxford-street, Manchester.
1874. ‡Sinclair, Thomas. Dunedin, Belfast.
1870. *Sinclair, W. P. Rivelyn, Prince's Park, Liverpool.
1864. *Sircar, The Hon. Mohendra Lal, M.D., C.I.E. 51 Sankaritola, Calcutta.
1892. ‡Sisley, Richard, M.D. 11 York-street, Portman-square, London, W.
1879. ‡Skertchly, Sydney B. J. 3 Loughborough-terrace, Carshalton, Surrey.
1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.
1885. ‡Skinner, Provost. Inverurie, N.B.
1892. ‡Skinner, William. 35 George-square, Edinburgh.
1888. §SKRINE, H. D., J.P., D.L. Claverton Manor, Bath.
1870. §SLADEN, WALTER PERCY, F.G.S., F.L.S. 13 Hyde Park-gate, London, S.W.
1873. ‡Slater, Clayton. Barnoldswick, near Leeds.
1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.
1884. ‡Slattery, James W. 9 Stephen's-green, Dublin.
1877. ‡Sleeman, Rev. Philip, L.Th., F.R.A.S., F.G.S. Clifton, Bristol.
1891. §Slocombe, James. Redland House, Fitzalan, Cardiff.
1884. ‡Slooten, William Venn. Nova Scotia, Canada.
1849. ‡Sloper, George Elgar. Devizes.
1887.§§Small, Evan W., M.A., B.Sc., F.G.S. County Council Offices, Newport, Monmouthshire.
1887. §Small, William. Lincoln-circus, The Park, Nottingham.
1881. ‡*Smallshan, John. 81 Manchester-road, Southport.*
1885. §Smart, James. Valley Works, Brechin, N.B.
1889. *Smart, William, LL.D. Nunholme, Dowanhill, Glasgow.
1858. ‡*Smeeton, G. H. Commercial-street, Leeds.*
1876. ‡Smellie, Thomas D. 213 St. Vincent-street, Glasgow.
1877. ‡Smelt, Rev. Maurice Allen, M.A., F.R.A.S. Heath Lodge, Cheltenham.
1890. §Smethurst, Charles. Palace House, Harpurhey, Manchester.
1876. ‡Smieton, James. Panmure Villa, Broughty Ferry, Dundee.
1876. ‡Smieton, John G. 3 Polworth-road, Coventry Park, Streatham, London, S.W.
1867. ‡Smieton, Thomas A. Panmure Villa, Broughty Ferry, Dundee.

Year of Election.

1892. ‡SMITH, ADAM GILLIES, F.R.S.E. 35 Drumsheugh-gardens, Edinburgh.
1892. ‡Smith, Alexander, B.Sc., Ph.D., F.R.S.E. The University, Chicago, Illinois, U.S.A.
1872. *Smith, Basil Woodd, F.R.A.S. Branch Hill Lodge, Hampstead Heath, London, N.W.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, London, S.W.
1887. ‡Smith, Bryce. Rye Bank, Chorlton-cum-Hardy, Manchester.
1873. ‡Smith, C. Sidney College, Cambridge.
1887. *Smith, Charles. 739 Rochdale-road, Manchester.
1889. *Smith, Professor C. Michie, B.Sc., F.R.S.E., F.R.A.S. The Observatory, Madras.
1865. ‡SMITH, DAVID, F.R.A.S. 40 Bennett's-hill, Birmingham.
1886. ‡Smith, Edwin. 33 Wheeley's-road, Edgbaston, Birmingham.
1886. *Smith, Mrs. Emma. Hencotes House, Hexham.
1886. ‡Smith, E. Fisher, J.P. The Priory, Dudley.
1886. ‡Smith, E. O. Council House, Birmingham.
1892. ‡Smith, E. Wythe. 66 College-street, Chelsea, London, S.W.
1866. *Smith, F. C. Bank, Nottingham.
1887. §SMITH, Rev. F. J., M.A., F.R.S. Trinity College, Oxford.
1892. ‡Smith, Rev. Frederick. 16 Grafton-street, Glasgow.
1885. ‡Smith, Rev. G. A., M.A. 21 Sardinia-terrace, Glasgow.
1860. *Smith, Heywood, M.A., M.D. 18 Harley-street, Cavendish-square, London, W.
1870. ‡Smith, H. L. Crabwall Hall, Cheshire.
1889. *Smith, H. Llewellyn, B.A., B.Sc., F.S.S. 49 Beaumont-square, London, E.
1888. ‡Smith, H. W. Owens College, Manchester.
1885. ‡Smith, Rev. James, B.D. Manse of Newhills, N.B.
1876. *Smith, J. Guthrie. 54 West Nile-street, Glasgow.
Smith, John Peter George. Sweyney Cliff, Coalport, Iron Bridge, Shropshire.
1883. ‡Smith, M. Holroyd. Royal Insurance Buildings, Crossley-street, Halifax.
1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.
1885. ‡SMITH, ROBERT H., M.Inst.C.E., Professor of Engineering in the Mason Science College, Birmingham.
1870. ‡Smith, Samuel. Bank of Liverpool, Liverpool.
1866. ‡Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.
1873. ‡Smith, Swire. Lowfield, Keighley, Yorkshire.
1867. ‡Smith, Thomas. Dundee.
1867. ‡Smith, Thomas. Poole Park Works, Dundee.
1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hornsea Burton, East Yorkshire.
1894. §Smith, T. Walrond. 137 Victoria Street, Westminster, S.W.
1884. ‡Smith, Vernon. 127 Metcalfe-street, Ottawa, Canada.
1892. ‡Smith, Walter A. 120 Princes-street, Edinburgh.
1885. *Smith, Watson. University College, London, W.C.
1887. ‡SMITH, Dr. WILBERFORCE. 14 Stratford-place, London, W.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1875. *Smith, William. Sundon House, Clifton Downs, Bristol.
1876. ‡Smith, William. 12 Woodside-place, Glasgow.
1883. ‡SMITHELLS, ARTHUR, B.Sc., Professor of Chemistry in the Yorkshire College, Leeds.
1883. ‡Smithson, Edward Walter. 13 Lendal, York.
1883. ‡Smithson, Mrs. 13 Lendal, York.

Year of Election.

1892. §Smithson, G. E. T. Tyneside Geographical Society, Barras Bridge, Newcastle-upon-Tyne.
1882. §§Smithson, T. Spencer. Facit, Rochdale.
1874. ‡Smoothy, Frederick. Bocking, Essex.
1850. *SMYTH, CHARLES PIAZZI, F.R.S.E., F.R.A.S. Clova, Ripon.
1883. ‡Smyth, Rev. Christopher. Firwood, Chalford, Stroud.
1874. ‡Smyth, Henry. Eastern Villa, Newcastle, Co. Down, Ireland.
1857. *SMYTH, JOHN, M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1888. *SNAPE, H. LLOYD, D.Sc., Ph.D., F.C.S., Professor of Chemistry in University College, Aberystwith.
1888. ‡Snell, Albion T. Brightside, Salusbury-road, Brondesbury, London, N.W.
1887. ‡Snell, Rev. Bernard J., M.A. 5 Park-place, Broughton, Manchester.
1878. §Snell, H. Saxon. 22 Southampton-buildings, London, W.C.
1889. ‡Snell, W. H. Lamorna, Oxford-road, Putney, S.W.
1879. *SOLLAS, W. J., M.A., D.Sc., F.R.S., F.R.S.E., F.G.S., Professor of Geology in the University of Dublin. Trinity College, and Lisnabin, Dartry Park-road, Rathgar, Dublin.
1892. *Somervail, Alexander. Torquay.
Sorbey, Alfred. The Rookery, Ashford, Bakewell.
1859. *SORBY, H. CLIFTON, LL.D., F.R.S., F.G.S. Broomfield, Sheffield.
1879. *Sorby, Thomas W. Storthfield, Runmoor, Sheffield.
1892. ‡Sorley, James, F.R.S.E. 18 Magdala-crescent, Edinburgh.
1888. ‡Sorley, Professor W. R. University College, Cardiff.
1886. ‡Southall, Alfred. Carrick House, Richmond Hill-road, Birmingham.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1859. ‡*Southall, Norman. 44 Cannon-street West, London, E.C.*
1887. §Sowerbutts, Eli, F.R.G.S. 44 Brown-street, Manchester.
1883. ‡Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.
1890. ‡Spark, F. R. 29 Hyde-terrace, Leeds.
1863. *Spark, H. King, F.G.S. Startforth House, Barnard Castle.
1893. *Speak, John. Kirton Grange, Kirton, near Boston.
1889. ‡*Spence, Faraday. 67 Grey-street, Hexham.*
1887. ‡Spencer, F. M. Fernhill, Knutsford.
1884. §Spencer, John, M.Inst.M.E. Globe Tube Works, Wednesbury.
1889. *Spencer, John. Newburn, Newcastle-upon-Tyne.
1891. *Spencer, Richard Evans. 6 Working-street, Cardiff.
1863. *Spencer, Thomas. The Grove, Ryton, Blaydon-on-Tyne, Co. Durham.
1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen Park, Highbury, London, N.
1894. §§Spiers, A. H. Newton College, South Devon.
1864. *SPILLER, JOHN, F.C.S. 2 St. Mary's-road, Canonbury, London, N.
1878. §Spottiswoode, George Andrew. 3 Cadogan-square, London, S.W.
1864. *Spottiswoode, W. Hugh, F.C.S. 41 Grosvenor-place, London, S.W.
1854. *SPRAGUE, THOMAS BOND, M.A., LL.D., F.R.S.E. 26 St. Andrew-square, Edinburgh.
1883. ‡Spratling, W. J., B.Sc., F.G.S. Maythorpe, 74 Wickham-road, Brockley, S.E.
1888. ‡Spreat, John Henry. Care of Messrs. Vines & Froom, 75 Aldersgate-street, London, E.C.
1884. *Spruce, Samuel, F.G.S. Beech House, Tamworth.

Year of Election.

1877. ‡SQUARE, WILLIAM, F.R.C.S., F.R.G.S. 4 Portland-square, Plymouth.
*Squire, Lovell. 5 Munster-terrace, Fulham, London, S.W.
1888. *Stacy, J. Sargeant. 7 and 8 Paternoster-row, London, E.C.
1884. ‡Stancoffe, Frederick. Dorchester-street, Montreal, Canada.
1892. ‡Stanfield, Richard, Assoc.M.Inst.C.E., F.R.S.E., Professor of Engineering in the Heriot Watt College, Edinburgh. 49 Mayfield-road, Edinburgh.
1883. *Stanford, Edward, jun., F.R.G.S. Thornbury, Bromley, Kent.
1865. ‡STANFORD, EDWARD C. C., F.C.S. Glenwood, Dalmuir, N.B.
1881. *Stanley, William Ford, F.G.S. Cumberlow, South Norwood, Surrey, S.E.
1883. ‡Stanley, Mrs. Cumberlow, South Norwood, Surrey, S.E.
1894. §Stansfield, Alfred. Royal Mint, London, E.
1893. ‡Staples, Sir Nathaniel, Bart. Lisson, Cookstown, Ireland.
Stapleton, M. H., M.B., M.R.I.A. 1 Mountjoy-place, Dublin.
1883. ‡Stapley, Alfred M. Marion-terrace, Crewe.
1876. ‡Starling, John Henry, F.C.S. 3 Victoria-road, Old Charlton, Kent.
Staveley, T. K. Ripon, Yorkshire.
1894. §§Stavert, Rev. W. J., M.A., F.C.S. Burnsall Rectory, Skipton-in-Craven, Yorkshire.
1873. *Stead, Charles. Red Barn, Freshfield, Liverpool.
1881. ‡Stead, W. H. Orchard-place, Blackwall, London, E.
1881. ‡Stead, Mrs. W. H. Orchard-place, Blackwall, London, E.
1884. ‡Stearns, Sergeant P. U.S. Consul-General, Montreal, Canada.
1892. *STEBBING, Rev. THOMAS R. R., M.A. Ephraim Lodge, The Common, Tunbridge Wells.
1891. ‡Steeds, A. P. 15 St. Helen's-road, Swansea.
1873. ‡Steinthal, G. A. 15 Hallfield-road, Bradford, Yorkshire.
1887. ‡Steinthal, Rev. S. Alfred. 81 Nelson-street, Manchester.
1887. ‡Stelfox, John L. 6 Hilton-street, Oldham, Manchester.
1884. ‡Stephen, George. 140 Drummond-street, Montreal, Canada.
1884. ‡Stephen, Mrs. George. 140 Drummond-street, Montreal, Canada.
1884. *Stephens, W. Hudson. Lowville, Lewis County, State of New York, U.S.A.
1879. *STEPHENSON, Sir HENRY, J.P. The Glen, Sheffield.
1870. **Stevens, Miss Anna Maria.* 23 *Elm Grove-terrace, London-road, Salisbury.*
1880. *Stevens, J. Edward, LL.B. Le Mayals, near Swansea.
1886. ‡Stevens, Marshall. Highfield House, Urmston, near Manchester.
1892. ‡Stevenson, D. A., B.Sc., F.R.S.E., M.Inst.C.E. 84 George-street, Edinburgh.
1863. *STEVENSON, JAMES C., F.C.S. Westoe, South Shields.
1889. ‡*Stevenson, T. Shannon. Westoe, South Shields.*
1890. *Steward, Rev. Charles J., F.R.M.S. Somerleyton Rectory, Lowestoft.
1885. *Stewart, Rev. Alexander, M.D., LL.D. Heathcot, Aberdeen.
1887. *Stewart, A. H. St. Thomas's Hospital, London, S.E.
1892. ‡Stewart, C. Hunter. 3 Carlton-terrace, Edinburgh.
1864. ‡STEWART, CHARLES, M.A., F.L.S. St. Thomas's Hospital, London, S.E.
1885. ‡Stewart, David. Banchory House, Aberdeen.
1886. *Stewart, Duncan. 12 Montgomerie-crescent, Kelvinside, Glasgow.
1887. ‡*Stewart, George N. Physiological Laboratory, Owens College, Manchester.*
1875. *Stewart, James, B.A., F.R.C.P.Ed. Dunmurry, Sneyd Park, near Clifton, Gloucestershire.
1892. §§Stewart, Samuel. Knocknairn, Bagston, Greenock.

Year of Election.

1876. ‡Stewart, William. Violet Grove House, St. George's-road, Glasgow.
1867. ‡Stirling, Dr. D. Perth.
1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Owens College, Manchester.
1867. *Stirrup, Mark, F.G.S. Stamford-road, Bowdon, Cheshire.
1865. *Stock, Joseph S. St. Mildred's, Walmer.
1890. ‡Stockdale, R. The Grammar School, Leeds.
1883. *STOCKER, W. N., M.A., Professor of Physics in the Royal Indian Engineering College. Cooper's Hill, Staines.
1845. *STOKES, Sir GEORGE GABRIEL, Bart., M.A., D.C.L., LL.D., D.Sc., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge. Lensfield Cottage, Cambridge.
1887. ‡Stone, E. D., F.C.S. 19 Lever-street, Piccadilly, Manchester.
1862. ‡STONE, EDWARD JAMES, M.A., Ph.D., F.R.S., F.R.A.S., Director of the Radcliffe Observatory, Oxford.
1886. ‡Stone, J. B. The Grange, Erdington, Birmingham.
1886. ‡Stone, J. H. Grosvenor-road, Handsworth, Birmingham.
1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 3 Dr. Johnson's-buildings, Temple, London, E.C.
1888. ‡STONE, JOHN. 15 Royal-crescent, Bath.
1876. ‡Stone, Octavius C., F.R.G.S. 49 Bolsover-street, Regent's Park, London, N.W.
1883. ‡Stone, Thomas William. 189 Goldhawk-road, Shepherd's Bush, London, W.
1857. ‡STONEY, BINDON B., LL.D., F.R.S., M.Inst.C.E., M.R.I.A., Engineer of the Port of Dublin. 14 Elgin-road, Dublin.
1895. *Stoney, Miss Edith A. 8 Upper Hornsey Rise, London, N.
1895. *Stoney, F.G.M., M.Inst.C.E. Tumbricane, Ipswich.
1878. *Stoney, G. Gerald. 90 Meldon-terrace, Newcastle-upon-Tyne.
1861. *STONEY, GEORGE JOHNSTONE, M.A., D.Sc., F.R.S., M.R.I.A. 8 Upper Hornsey Rise, London, N.
1876. §Stopes, Henry, F.G.S. 31 Torrington-square, London, W.C.
1883. ‡Stopes, Mrs. 31 Torrington-square, London, W.C.
1887. ‡Storer, Edwin. Woodlands, Crumpsall, Manchester.
1887. *Storey, H. L. Caton, near Lancaster.
1873. §Storr, William. The 'Times' Office, Printing-house-square, London, E.C.
1884. §Storrs, George H. Gorse Hall, Stalybridge.
1888. *Stothert, Percy K. Audley, Park-gardens, Bath.
1874. ‡Stott, William. Scar Bottom, Greetland, near Halifax, Yorkshire.
1871. *STRACHEY, Lieut.-General RICHARD, R.E., C.S.I., LL.D., F.R.S., F.R.G.S., F.L.S., F.G.S. 69 Lancaster-gate, Hyde Park, London, W.
1881. ‡Strahan, Aubrey, M.A., F.G.S. Geological Museum, Jermyn-street, London, S.W.
1876. ‡Strain, John. 143 West Regent-street, Glasgow.
1863. ‡Straker, John. Wellington House, Durham.
1889. ‡Straker, Captain Joseph. Dilston House, Riding Mill-on-Tyne.
1882. ‡Strange, Rev. Cresswell, M.A. Edgbaston Vicarage, Birmingham.
1881. ‡Strangways, C. Fox, F.G.S. Geological Museum, Jermyn-street, London, S.W.
1889. §Streatfeild, H. S., F.G.S. The Limes, Leigham Court-road, Streatham, S.W.
*Strickland, Charles. 21 Fitzwilliam-place, Dublin.
1879. ‡Strickland, Sir Charles W., K.C.B. Hildenley-road, Malton.
1884. ‡Stringham, Irving. The University, Berkeley, California, U.S.A.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.

Year of Election.

1883. §Strong, Henry J., M.D. Colonnade House, The Steyne, Worthing.
1887. *Stroud, Professor H., M.A., D.Sc. College of Science, Newcastle-upon-Tyne.
1887. *Stroud, William, D.Sc., Professor of Physics in the Yorkshire College, Leeds.
1876. *Struthers, John, M.D., LL.D., Emeritus Professor of Anatomy in the University of Aberdeen. 24 Buckingham-terrace, Edinburgh.
1878. ‡Strype, W. G. Wicklow.
1876. *Stuart, Charles Maddock. St. Dunstan's College, Catford, S.E.
1872. *Stuart, Rev. Edward A., M.A. St. Matthew, Bayswater, 5 Prince's-square, London, W.
1892. ‡Stuart, Morton Gray, M.A. Ettrickbank, Selkirk.
1884. ‡Stuart, Dr. W. Theophilus. 183 Spadina-avenue, Toronto, Canada.
1893. ‡Stubbs, Arthur G. Sherwood Rise, Nottingham.
1888. *Stubbs, Rev. Elias T., M.A. 4 Springfield-place, Bath.
1885. §Stump, Edward C. 16 Herbert-street, Moss Side, Manchester.
1879. *Styring, Robert. 64 Crescent-road, Sheffield.
1891. *Sudborough, J. J., Ph.D., B.Sc. 9 Park-grove, Wordsworth-road, Birmingham.
1884. ‡Sumner, George. 107 Stanley-street, Montreal, Canada.
1887. ‡Sumpner, W. E. 37 Pennyfields, Poplar, London, E.
1888. ‡Sunderland, John E. Bark House, Hatherlow, Stockport.
1883. ‡Sutcliffe, J. S., J.P. Beech House, Bacup.
1873. ‡Sutcliffe, Robert. Idle, near Leeds.
1863. ‡Sutherland, Benjamin John. Thurso House, Newcastle-upon-Tyne.
1886. ‡Sutherland, Hugh. Winnipeg, Manitoba, Canada.
1892. §§Sutherland, James B. 10 Windsor-street, Edinburgh.
1884. ‡Sutherland, J. C. Richmond, Quebec, Canada.
1863. ‡Sutton, Francis, F.C.S. Bank Plain, Norwich.
1889. ‡Sutton, William. Esbank, Jesmond, Newcastle-upon-Tyne.
1891. ‡Swainson, George, F.L.S. North Drive, St. Anne's-on-Sea, Lancashire.
1881. ‡Swales, William. Ashville, Holgate Hill, York.
1876. ‡*Swan, David, jun. Braeside, Maryhill, Glasgow.*
1881. §§Swan, Joseph Wilson, M.A., F.R.S. Lauriston, Bromley, Kent.
1879. ‡Swanwick, Frederick. Whittington, Chesterfield.
1883. ‡Sweeting, Rev. T. E. 50 Roe-lane, Southport.
1887. §Swinburne, James. 4 Hatherley-road, Kew Gardens, London.
1870. *Swinburne, Sir John, Bart. Capheaton, Newcastle-upon-Tyne.
1885. ‡*Swindells, Miss. Springfield House, Ilkley, Yorkshire.*
1887. *Swindells, Rupert, F.R.G.S. Wilton Villa, The Firs, Bowdon, Cheshire.
1890. §Swinhoe, Colonel C. Avenue House, Oxford.
1891. ‡Swinnerton, R. W., Assoc.M.Inst.C.E. Bolarum, Dekkan, India.
1889. §Sworn, Sidney A., B.A., F.C.S. The Municipal Technical School, Gravesend.
1873. ‡Sykes, Benjamin Clifford, M.D. St. John's House, Cleckheaton.
1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. Glencoe, Elmbourne-road, Tooting Common, London, S.W.
1895. §Sykes, E. R. 9 Belvidere, Weymouth.
1890. ‡Sykes, Joseph. 113 Beeston-hill, Leeds.
1887. *Sykes, T. H. Cringle House, Cheadle, Cheshire.
Sylvester, James Joseph, M.A., D.C.L., LL.D., F.R.S., Savilian Professor of Geometry in the University of Oxford. Athenæum Club, London, S.W.
1893. ‡Symes, Rev. J. E., M.A. 70 Redcliffe-crescent, Nottingham.

Year of Election.

1870. ‡SYMES, RICHARD GLASCOTT, M.A., F.G.S., Geological Survey of Scotland. Sheriff Court-buildings, Edinburgh.
1885. ‡Symington, Johnson, M.D. Queen's College, Belfast.
1881. *Symington, Thomas. Wardie House, Edinburgh.
1859. §SYMONS, G. J., F.R.S., Sec.R.Met.Soc. 62 Camden-square, London, N.W.
1855. *SYMONS, WILLIAM, F.C.S. Dragon House, Bilbrook, near Taunton.
1886. §Symons, W. H., M.D. (Brux.), M.R.C.P., F.I.C. 53 Dynham-road, West Hampstead, London, N.W.
1872. ‡*Synge, Major-General Millington, R.E., F.R.G.S. United Service Club, Pall Mall, London, S.W.*

1865. ‡Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N.B.
1877. *TAIT, LAWSON, F.R.C.S. The Crescent, Birmingham.
1871. ‡TAIT, PETER GUTHRIE, F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh. George-square, Edinburgh.
1867. ‡Tait, P. M., F.S.S. 37 Charlotte-street, Portland-place, London, W.
1894. §§Takakusu, Jyun, B.A. 17 Worcester-terrace, Oxford.
1890. ‡Talbot, Rev. E. S. The Vicarage, Leeds.
1893. ‡Talbot, Herbert, M.I.E.E. 19 Addison-villas, Addison-street, Nottingham.
1891. ‡Tamblyn, James. Glan Llynvi, Maesteg, Bridgend.
1891. ‡Tanner, Colonel H. C. B., F.R.G.S. Fièsole, Bathwick Hill, Bath.
1890. ‡TANNER, H. W. LLOYD, M.A., Professor of Mathematics and Astronomy in University College, Cardiff.
1892. *Tansley, Arthur G. 167 Adelaide-road, London, N.W.
1883. *Tapscott, R. Lethbridge, Assoc.M.Inst.C.E., F.G.S., F.R.A.S. Woodlands Park, Altrincham, Cheshire.
1878. ‡TARPEY, HUGH. Dublin.
1861. *Tarratt, Henry W. 25 Manchester-square Mansions, W.
1857. *Tate, Alexander. Rantalard, Whitehouse, Belfast.
1893. ‡Tate, George, Ph.D., F.C.S. College of Chemistry, Duke-street, Liverpool.
1890. ‡Tate, Thomas, F.G.S. 5 Eldon-mount, Woodhouse-lane, Leeds.
1858. *Tatham, George, J.P. Springfield Mount, Leeds.
1884. *Taylor, Rev. Charles, D.D. St. John's Lodge, Cambridge.
Taylor, Frederick. Laurel Cottage, Rainhill, near Prescot, Lancashire.
1887. §Taylor, G. H. Holly House, 235 Eccles New-road, Salford.
1874. ‡Taylor, G. P. Students' Chambers, Belfast.
1887. ‡Taylor, George Spratt, F.C.S. 13 Queen's-terrace, St. John's Wood, London, N.W.
1881. *Taylor, H. A. 25 Collingham-road, South Kensington, S.W.
1884. *Taylor, H. M., M.A. Trinity College, Cambridge.
1882. *Taylor, Herbert Owen, M.D. Oxford-street, Nottingham.
1887. ‡TAYLOR, Rev. Canon ISAAC, D.D. Settrington Rectory, York.
1861. *Taylor, John, M.Inst.C.E., F.G.S. The Old Palace, Richmond, Surrey.
1881. *Taylor, John Francis. Holly Bank House, York.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
1876. ‡Taylor, Robert. 70 Bath-street, Glasgow.
1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.
1881. ‡Taylor, Rev. S. B., M.A. Whixley Hall, York.
1883. ‡Taylor, S. Leigh. Birklands, Westcliffe-road, Birkdale, Southport.
1870. ‡Taylor, Thomas. Aston Rowant, Tetsworth, Oxon.

Year of Election.

1887. ‡Taylor, Tom. Grove House, Sale, Manchester.
1883. ‡Taylor, William, M.D. 21 Crockherbtown, Cardiff.
1895. §Taylor, W. A., M.A., F.R.S.E. Royal Scottish Geographical Society, Edinburgh.
1893.§§Taylor, W. F. Bhootan, Whitehorse Road, Croydon, Surrey.
1894. *Taylor, W. W. 10 King-street, Oxford.
1884. ‡Taylor-Whitehead, Samuel, J.P. Burton Closes, Bakewell.
1858. ‡TEALE, THOMAS PRIDGIN, M.A., F.R.S. 38 Cookridge-street, Leeds.
1885. ‡TEALL, J. J. H., M.A., F.R.S., F.G.S. 28 Jermyn-street, S.W.
1879. ‡Temple, Lieutenant G. T., R.N., F.R.G.S. The Nash, near Worcester.
1880. ‡TEMPLE, Sir RICHARD, Bart., G.C.S.I., C.I.E., D.C.L., LL.D., F.R.G.S. Athenæum Club, London, S.W.
1863. ‡Tennant, Henry. Saltwell, Newcastle-upon-Tyne.
1889. ‡Tennant, James. Saltwell, Gateshead.
1894. §Terras, J. A., B.Sc. Royal Botanic Gardens, Edinburgh.
1882. §Terrill, William. 42 St. George's-terrace, Swansea.
1881. ‡Terry, Sir Joseph. Hawthorn Villa, York.
1892. *Tesla, Nikola. 45 West 27th-street, New York, U.S.A.
1883. ‡Tetley, C. F. The Brewery, Leeds.
1883. ‡Tetley, Mrs. C. F. The Brewery, Leeds.
1882. *Thane, George Dancer, Professor of Anatomy in University College, Gower-street, London, W.C.
1885. ‡Thin, Dr. George, 22 Queen Anne-street, London, W.
1871. ‡Thin, James. 7 Rillbank-terrace, Edinburgh.
1871. ‡THISELTON-DYER, W. T., C.M.G., C.I.E., M.A., B.Sc., Ph.D., F.R.S., F.L.S. Royal Gardens, Kew.
1870. ‡Thom, Robert Wilson. Lark-hill, Chorley, Lancashire.
1891. ‡Thomas, Alfred, M.P. Pen-y-lan, Cardiff.
1871. ‡Thomas, Ascanius William Nevill. Chudleigh, Devon.
1891. ‡Thomas, A. Garrod, M.D., J.P. Clytha Park, Newport, Monmouthshire.
1891. *Thomas, Miss Clara. Llwynmadoc, Garth, R.S.O.
1891. ‡Thomas, Edward. 282 Bute-street, Cardiff.
1891. §Thomas, E. Franklin. Dan-y-Bryn, Radyr, near Cardiff.
1883. ‡*Thomas, Ernest C., B.A. 13 South-square, Gray's Inn, London, W.C.*
1884. ‡THOMAS, F. WOLFERSTAN. Molson's Bank, Montreal, Canada.
Thomas, George. Brislington, Bristol.
1875. ‡Thomas, Herbert. Ivor House, Redland, Bristol.
1869. ‡Thomas, H. D. Fore-street, Exeter.
1881. §THOMAS, J. BLOUNT. Southampton.
1892. ‡*Thomas, J. C., B.Sc. Queen Elizabeth's Grammar School, Carmarthen.*
1869. ‡Thomas, J. Henwood, F.R.G.S. Custom House, London, E.C.
1891. ‡Thomas, John Tubb, L.R.C.P. Eastfields, Newport, Monmouthshire.
1880. *Thomas, Joseph William, F.C.S. Drumpellier, Brunswick-road, Gloucester.
1883.§§Thomas, Thomas H. 45 The Walk, Cardiff.
1883. ‡Thomas, William. Lan, Swansea.
1886. ‡Thomas, William. 109 Tettenhall-road, Wolverhampton.
1886. ‡Thomason, Yeoville. 9 Observatory-gardens, Kensington, London, W.
1875. ‡Thompson, Arthur. 12 St. Nicholas-street, Hereford.
1891. *Thompson, Beeby, F.C.S., F.G.S. 55 Victoria-road, Northampton.
1883. ‡Thompson, Miss C. E. Heald Bank, Bowdon, Manchester.
1891. ‡Thompson, Charles F. Penhill Close, near Cardiff.

Year of Election.

1882. ‡Thompson, Charles O. Terre Haute, Indiana, U.S.A.
1888. *Thompson, Claude M., M.A., Professor of Chemistry in University College, Cardiff.
1885. ‡Thompson, D'Arcy W., B.A., Professor of Zoology in University College, Dundee. University College, Dundee.
1883. *Thompson, Francis. Lynton, Haling Park-road, Croydon.
1891. ‡Thompson, G. Carslake. Park-road, Penarth.
1859. ‡Thompson, George, jun. 5 Golden-square, Aberdeen.
1893. *Thompson, Harry J., M.Inst.C.E., Madras. Care of Messrs. Grindlay & Co., Parliament-street, London, S.W.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
1870. ‡THOMPSON, Sir HENRY. 35 Wimpole-street, London, W.
1889. ‡*Thompson, Henry. 2 Eslington-terrace, Newcastle-upon-Tyne.*
1883. *Thompson, Henry G., M.D. 86 Lower Addiscombe-road, Croydon.
Thompson, Henry Stafford. Fairfield, near York.
1891. ‡Thompson, Herbert M. Whitley Batch, Llandaff.
1891. ‡Thompson, H. Wolcott. 9 Park-place, Cardiff.
1883. *THOMPSON, ISAAC COOKE, F.L.S., F.R.M.S. (LOCAL SECRETARY.) Woodstock, Waverley-road, Liverpool.
1891. ‡Thompson, J. Tatham. 23 Charles-street, Cardiff.
1861. *THOMPSON, JOSEPH. Riversdale, Wilmslow, Manchester.
1876. *Thompson, Richard. Dringcote, The Mount, York.
1883. ‡Thompson, Richard. Bramley Mead, Whalley, Lancashire.
1876. ‡THOMPSON, SILVANUS PHILLIPS, B.A., D.Sc., F.R.S., F.R.A.S., Principal and Professor of Physics in the City and Guilds of London Technical College, Finsbury, E.C.
1883. *Thompson, T. H. Redlynet House, Green Walk, Bowdon, Cheshire.
1867. ‡Thoms, William. Magdalen-yard-road, Dundee.
1894. §§Thomson, Arthur, M.D., Professor of Human Anatomy in the University of Oxford. Exeter College, Oxford.
1889. *Thomson, James, M.A. 22 Wentworth-place, Newcastle-upon-Tyne.
1868. §THOMSON, JAMES, F.G.S. 6 Stewart-street, Shawlands, Glasgow.
1876. ‡Thomson, James R. Mount Blow, Dalmuir, Glasgow.
1891. ‡Thomson, John. 70A Grosvenor-street, London, W.
1890. §§Thomson, J. Arthur, M.A., F.R.S.E., Lecturer on Zoology at the School of Medicine, Edinburgh. 11 Ramsay-garden, Edinburgh.
1883. ‡THOMSON, J. J., M.A., D.Sc., F.R.S., Professor of Experimental Physics in the University of Cambridge. 6 Scrope-terrace, Cambridge.
1871. *THOMSON, JOHN MILLAR, F.C.S., Professor of Chemistry in King's College, London. 53 Prince's-square, London, W.
1874. §THOMSON, WILLIAM, F.R.S.E., F.C.S. Royal Institution, Manchester.
1880. §Thomson, William J. Ghyllbank, St. Helens.
1871. ‡Thornburn, Rev. David, M.A. 1 John's-place, Leith.
1886. §§Thornley, J. E. Lyndon, Bickenhill, near Birmingham.
1887. ‡Thornton, John. 3 Park-street, Bolton.
1867. ‡Thornton, Sir Thomas. Dundee.
1883. §Thorowgood, Samuel. Castle-square, Brighton.
1845. ‡Thorp, Dr. Disney. Lypiatt Lodge, Suffolk Lawn, Cheltenham.
1881. ‡Thorp, Fielden. Blossom-street, York.
1871. ‡Thorp, Henry. Briarleigh, Sale, near Manchester.
1881. *Thorp, Josiah. Undercliffe, Holmfirth.
1864. *THORP, WILLIAM, B.Sc., F.C.S. 24 Crouch Hall-road, Crouch End, London, N.
1871. ‡THORPE, T. E., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S., Principal of the Government Laboratories, Somerset House, London, W.C.

Year of Election.

1883. §Threlfall, Henry Singleton. 12 London-street, Southport.
1868. ‡THUILLIER, General Sir H. E. L., R.A., C.S.I., F.R.S., F.R.G.S. Tudor House, Richmond Green, Surrey.
1889. ‡Thys, Captain Albert. 9 Rue Briderode, Brussels.
1870. ‡Tichborne, Charles R. C., LL.D., F.C.S., M.R.I.A. Apothecaries' Hall of Ireland, Dublin.
1873. *TIDDEMAN, R. H., M.A., F.G.S. 28 Jermyn-street, London, S.W.
1874. ‡TILDEN, WILLIAM A., D.Sc., F.R.S., F.C.S., Professor of Chemistry in the Royal College of Science, South Kensington, London, S.W.
1873. ‡Tilghman, B. C. Philadelphia, U.S.A.
1883. ‡Tillyard, A. I., M.A. Fordfield, Cambridge.
1883. ‡Tillyard, Mrs. Fordfield, Cambridge.
1865. ‡Timmins, Samuel, J.P., F.S.A. Hill Cottage, Fillongley, Coventry.
1876. ‡Todd, Rev. Dr. Tudor Hall, Forest Hill, London, S.E.
1891. §Todd, Richard Rees. Portuguese Consulate, Cardiff.
1889. §Toll, John M. Carlton House, Kirkby, near Liverpool.
1887. ‡*Tolmé, Mrs. Melrose House, Higher Broughton, Manchester.*
1857. ‡Tombe, Rev. Canon. Glenealy, Co. Wicklow.
1888. ‡Tomkins, Rev. Henry George. Park Lodge, Weston-super-Mare.
1864. *TOMLINSON, CHARLES, F.R.S., F.C.S. 7 North-road, Highgate, London, N.
1887. ‡Tonge, Rev. Canon. Chorlton-cum-Hardy, Manchester.
1887. ‡Tonge, James. Woodbine House, West Houghton, Bolton.
1865. ‡Tonks, Edmund, B.C.L. Packwood Grange, Knowle, Warwickshire.
1865. *Tonks, William Henry. The Rookery, Sutton Coldfield.
1873. *Tookey, Charles, F.C.S. Royal School of Mines, Jermyn-street, London, S.W.
1887. ‡Topham, F. 15 Great George-street, London, S.W.
1886. ‡Topley, Mrs. W. 13 Havelock-road, Croydon.
1875. ‡Torr, Charles Hawley. St. Alban's Tower, Mansfield-road, Sherwood, Nottingham.
1886. ‡Torr, Charles Walker. Cambridge-street Works, Birmingham.
1884. ‡Torrance, John F. Folly Lake, Nova Scotia, Canada.
1884. *Torrance, Rev. Robert, D.D. Guelph, Ontario, Canada.
Towgood, Edward. St. Neot's, Huntingdonshire.
1873. ‡Townend, W. H. Heaton Hall, Bradford, Yorkshire.
1875. ‡Townsend, Charles. St. Mary's, Stoke Bishop, Bristol.
1861. ‡Townsend, William. Attleborough Hall, near Nuneaton.
1877. ‡Tozer, Henry. Ashburton.
1876. *TRAIL, J. W. H., M.A., M.D., F.R.S., F.L.S., Regius Professor of Botany in the University of Aberdeen.
1883. ‡TRAILL, A., M.D., LL.D. Ballylough, Bushmills, Ireland.
1870. ‡TRAILL, WILLIAM A. Giant's Causeway Electric Tramway, Portrush, Ireland.
1875. ‡*Trapnell, Caleb. Severnleigh, Stoke Bishop.*
1868. ‡TRAQUAIR, RAMSAY H., M.D., LL.D., F.R.S., F.G.S., Keeper of the Natural History Collections, Museum of Science and Art, Edinburgh.
1891. ‡Trayes, Valentine. Maindell Hall, near Newport, Monmouthshire.
1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.
1868. ‡Trehane, John. Exe View Lawn, Exeter.
1891. ‡Treharne, J. Ll. 92 Newport-road, Cardiff.
Trench, F. A. Newlands House, Clondalkin, Ireland.

Year of Election.

1887. *Trench-Gascoigne, Mrs. F. R. Parlington, Aberford, Leeds.
1883. ‡Trendell, Edwin James, J.P. Abbey House, Abingdon, Berks.
1884. ‡Trenham, Norman W. 18 St. Alexis-street, Montreal, Canada.
1884.§§Tribe, Paul C. M. 44 West Oneida-street, Oswego, New York, U.S.A.
1879. ‡Trickett, F. W. 12 Old Haymarket, Sheffield.
1877. ‡TRIMEN, HENRY, M.B., F.R.S., F.L.S. Peradeniya, Ceylon.
1871. ‡TRIMEN, ROLAND, F.R.S., F.L.S., F.Z.S.
1860. §TRISTRAM, Rev. HENRY BAKER, D.D., LL.D., F.R.S., Canon of Durham. The College, Durham.
1884. *Trotter, Alexander Pelham. 22 Cottesmore-gardens, Victoria-road, Kensington, London, W.
1885. §TROTTER, COUTTS, F.G.S., F.R.G.S. 17 Charlotte-square, Edinburgh.
1891. ‡Trounce, W. J. 67 Newport-road, Cardiff.
1887. *Trouton Frederick T., M.A.., D.Sc., Trinity College, Dublin.
1869. ‡Troyte, C. A. W. Huntsham Court, Bampton, Devon.
1885. *Tubby, A. H. 6 Versailles Road, Anerley, London, S.E.
1847. *Tuckett, Francis Fox. Frenchay, Bristol.
1888. ‡Tuckett, William Fothergill, M.D. 18 Daniel-street, Bath.
Tuke, James H. Bancroft, Hitchin.
1871. ‡Tuke, J. Batty, M.D. Cupar, Fifeshire.
1887. ‡Tuke, W. C. 29 Princess-street, Manchester.
1883. ‡TUPPER, The Hon. Sir CHARLES, Bart., G.C.M.G., C.B., High Commissioner for Canada. 9 Victoria-chambers, London, S.W.
1892. ‡Turnbull, Alexander R. Ormiston House, Hawick.
1855. ‡Turnbull, John. 37 West George-street, Glasgow.
1893. §Turner, Dawson, M.B. 37 George-square, Edinburgh.
1891. ‡Turner, Miss E. R. Ipswich.
1882. ‡Turner, G. S. Pitcombe, Winchester-road, Southampton.
1883. ‡Turner, Mrs. G. S. Pitcombe, Winchester-road, Southampton.
1894. *TURNER, H. H., M.A., B.Sc., Sec. R.A.S., Professor of Astronomy in the University of Oxford. The Observatory, Oxford.
1888. ‡Turner, J. S., J.P. Granville, Lansdowne, Bath.
1886. *TURNER, THOMAS, A.R.S.M., F.C.S., F.I.C. County Offices, Stafford.
1863. *TURNER, Sir WILLIAM, M.B., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Anatomy in the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1893. ‡TURNEY, Sir JOHN, J.P. Alexandra Park, Nottingham.
1890. *Turpin, G. S., M.A., D.Sc. 2 St. James's-terrace, Nottingham.
1883. ‡*Turrell, Miss S. S. High School, Redland-grove, Bristol.*
1884. *Tutin, Thomas. The Orchard, Chellaston, Derby.
1886. *Twigg, G. H. 56 Claremont Road, Handsworth, Birmingham.
1888. §Tyack, Llewellyn Newton. University College, Bristol.
1882. §Tyer, Edward. Horneck, 16 Fitzjohn's-avenue, Hampstead, London, N.W.
1865. §TYLOR, EDWARD BURNETT, D.C.L., LL.D., F.R.S., Professor of Anthropology, and Keeper of the Museum, Oxford University.
1883. ‡Tyrer, Thomas, F.C.S. Garden-wharf, Battersea, London, S.W.
1861. *Tysoe, John. Heald-road, Bowdon, near Manchester.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1888. ‡Underhill, H. M. 7 High-street, Oxford.
1886. ‡Underhill, Thomas, M.D. West Bromwich.
1885. §Unwin, Howard. Newton-grove, Bedford Park, Chiswick, London.

Year of
Election.

1883. §Unwin, John. Eastcliffe Lodge, Southport.
1883.§§Unwin, William Andrews. The Briars, Freshfield, near Liverpool.
1876. *UNWIN, W. C., F.R.S., M.Inst.C.E., Professor of Engineering at the Central Institution of the City and Guilds of London Institute. 7 Palace-gate Mansions, Kensington, London, W.
1887. ‡Upton, Francis R. Orange, New Jersey, U.S.A.
1872. ‡Upward, Alfred. 150 Holland-road, London, W.
1876. ‡Ure, John F. 6 Claremont-terrace, Glasgow.
1859. ‡Urquhart, W. Pollard. Craigston Castle, N.B.; and Castlepollard, Ireland.
1866. ‡Urquhart, William W. Rosebay, Broughty Ferry, by Dundee.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, London, S.W.

1885. ‡Vachell, Charles Tanfield, M.D. 38 Charles-street, Cardiff.
1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1888. ‡Vallentin, Rupert. 18 Kimberley-road, Falmouth.
1884. ‡Van Horne, Sir W. C., K.C.M.G. Dorchester-street West, Montreal, Canada.
1883. *Vansittart, The Hon. Mrs. A. A. Haywood House, Oaklands-road, Bromley, Kent.
1886. ‡VARDY, Rev. A. R., M.A. King Edward's School, Birmingham.
1868. ‡Varley, Frederick H., F.R.A.S. Mildmay Park Works, Mildmay-avenue, Stoke Newington, London, N.
1865. *VARLEY, S. ALFRED. 5 Gayton-road, Hampstead, London, N.W.
1870. ‡Varley, Mrs. S. A. 5 Gayton-road, Hampstead, London, N.W.
1869. ‡Varwell, P. Alphington-street, Exeter.
1884. ‡Vasey, Charles. 112 Cambridge-gardens, London, W.
1887. *VAUGHAN, His Eminence Cardinal. Carlisle-place, Westminster.
1875. ‡Vaughan, Miss. Burlton Hall, Shrewsbury.
1883. ‡Vaughan, William. 42 Sussex-road, Southport.
1895. §Vaughan, D. T. Gwynne. Howry Hall, Llandrindod, Radnorshire.
1881. §VELEY, V. H., M.A., F.R.S., F.C.S. 22 Norham-road, Oxford.
1873. *VERNEY, Sir EDMUND H., Bart., F.R.G.S. Claydon House, Winslow, Bucks.
1883. *Verney, Lady. Claydon House, Winslow, Bucks.
1883. ‡VERNON, H. H., M.D. York-road, Birkdale, Southport.
1864. *VICARY, WILLIAM, F.G.S. The Priory, Colleton-crescent, Exeter.
1890. *Villamil, Major R. de, R.E. Care of Messrs. Cox & Co., 16 Charing Cross, London, S.W.
1868. ‡Vincent, Rev. William. Postwick Rectory, near Norwich.
1883. *VINES, SYDNEY HOWARD, M.A., D.Sc., F.R.S., F.L.S., Professor of Botany in the University of Oxford. Headington Hill, Oxford.
1891. ‡Vivian Stephen. Llantrisant.

1886. *Wackrill, Samuel Thomas, J.P. Leamington.
1860. ‡Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1890. ‡Wadsworth, George Henry. 3 Southfield-square, Bradford, Yorkshire.
1888. ‡Wadworth, H. A. Breinton Court, near Hereford.
1890. §WAGER, HAROLD W. T. Yorkshire College, Leeds.
1891. ‡Wailes, T. W. 23 Richmond-road, Cardiff.
1884. ‡Wait, Charles E., Professor of Chemistry in the University of Tennessee. Knoxville, Tennessee, U.S.A.
1886. ‡Waite, J. W. The Cedars, Bestcot, Walsall.

Year of Election.

1870. ‡Wake, Charles Staniland. Welton, near Brough, East Yorkshire.
1892. ‡Walcot, John. 50 Northumberland-street, Edinburgh.
1884. ‡Waldstein, C., M.A., Ph.D. Slade Professor of Fine Art in the University of Cambridge.
1891. ‡Wales, H. T. Pontypridd.
1891. ‡Walford, Edward, M.D. Thanet House, Cathedral-road, Cardiff.
1894. §Walford, Edwin A., F.G.S. West Bar, Banbury.
1882. *Walkden, Samuel. Downside, Whitchurch, Tavistock.
1893. §Walker, Alfred O., F.L.S. Nant-y-Glyn, Colwyn Bay.
1890. §§Walker, A. Tannett. Hunslet, Leeds.
1885. ‡Walker, Mr. Baillie. 52 Victoria-street, Aberdeen.
1885. ‡Walker, C. C., F.R.A.S. Lillieshall Old Hall, Newport, Shropshire.
1883. §Walker, Mrs. Emma. 13 Lendal, York.
1883. ‡Walker, E. R. Pagefield Ironworks, Wigan.
1891. §§Walker, Frederick W. Hunslet, Leeds.
1883. ‡Walker, George. 11 Hamilton-square, Birkenhead, Liverpool.
1894. *Walker, G. T., M.A. Trinity College, Cambridge.
1866. ‡Walker, H. Westwood, Newport, by Dundee.
1890. ‡Walker, Dr. James. 8 Windsor-terrace, Dundee.
1894. *Walker, James, M.A. 30 Norham-gardens, Oxford.
1885. ‡Walker, General J. T., C.B., R.E., LL.D., F.R.S., F.R.G.S. 13 Cromwell-road, London, S.W.
1866. *Walker, John Francis, M.A., F.C.S., F.G.S., F.L.S. 45 Bootham, York.
1855. ‡Walker, John James, M.A., F.R.S. 12 Denning-road, Hampstead, London, N.W.
1867. *Walker, Peter G. 2 Airlie-place, Dundee.
1886. *Walker, Major Philip Billingsley. Sydney, New South Wales.
1866. ‡Walker, S. D. 38 Hampden-street, Nottingham.
1884. ‡Walker, Samuel. Woodbury, Sydenham Hill, London, S.E.
1888. ‡Walker, Sydney F. 195 Severn-road, Cardiff.
1887. ‡Walker, T. A. 15 Great George-street, London, S.W.
1883. ‡Walker, Thomas A. 66 Leyland-road, Southport.
Walker, William. 47 Northumberland-street, Edinburgh.
1881. *Walker, William, F.G.S. 14 Bootham-terrace, York.
1895. §Walker, W. G., A.M.Inst.C.E. 47 Victoria-street, London, S.W.
1883. ‡Wall, Henry. 14 Park-road, Southport.
1863. ‡Wallace, Alfred Russel, D.C.L., F.R.S., F.L.S., F.R.G.S. Corfe View, Parkstone, Dorset.
1892. ‡Wallace, Robert W. 14 Frederick-street, Edinburgh.
1887. *Waller, Augustus, M.D., F.R.S. Weston Lodge, 16 Grove End-road, London, N.W.
1889. *Wallis, Arnold J., M.A. 5 Belvoir-terrace, Cambridge.
1895. §Wallis, E. White, F.S.S. Sanitary Institute, Parkes Museum, Margaret-street, London, W.
1883. ‡Wallis, Rev. Frederick. Caius College, Cambridge.
1884. ‡Wallis, Herbert. Redpath-street, Montreal, Canada.
1886. ‡Wallis, Whitworth, F.S.A. Westfield, Westfield-road, Edgbaston, Birmingham.
1883. ‡Walmesley, Oswald. Shevington Hall, near Wigan.
1894. *Walmisley, A. T., M.Inst.C.E. 9 Victoria-street, London, S.W.
1887. ‡Walmsley, J. Monton Lodge, Eccles, Manchester.
1891. §Walmsley, Prof. R. M., D.Sc. Heriot Watt College, Edinburgh.
1883. ‡Walmsley, T. M. Clevelands, Chorley-road, Heaton, Bolton.
1862. ‡Walpole, The Right Hon. Spencer Horatio, M.A., D.C.L., F.R.S. Ealing, Middlesex, W.

Year of Election.

1895. §WALSINGHAM, The Right Hon. Lord, LL.D., F.R.S. Merton Hall, Thetford.
1881. ‡Walton, Thomas, M.A. Oliver's Mount School, Scarborough.
1863. ‡Wanklyn, James Alfred. 7 Westminster-chambers, London, S.W.
1884. ‡Wanless, John, M.D. 88 Union-avenue, Montreal, Canada.
1887. ‡Ward, A. W., M.A., Litt.D., Principal of Owens College, Manchester.
1874.§§Ward, F. D., J.P., M.R.I.A. Wyncroft, Adelaide Park, Belfast.
1881. §Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.
1879. ‡WARD, H. MARSHALL, D.Sc., F.R.S., F.L.S., Professor of Botany in the Royal Indian Civil Engineering College, Cooper's Hill, Egham.
1890. ‡Ward, Alderman John. Moor Allerton House, Leeds.
1874. §Ward, John, J.P., F.S.A. Lenoxvale, Belfast.
1887.§§WARD, JOHN, F.G.S. 23 Stafford-street, Longton, Staffordshire.
1857. ‡Ward, John S. Prospect Hill, Lisburn, Ireland.
1880. *Ward, J. Wesney. Red House, Ravensbourne Park, Catford, S.E.
1884. *Ward, John William. Newstead, Halifax.
1883. ‡Ward, Thomas, F.C.S. Arnold House, Blackpool.
1887. ‡Ward, Thomas. Brookfield House, Northwich.
1882. ‡Ward, William. Cleveland Cottage, Hill-lane, Southampton.
1867. ‡Warden, Alexander J. 23 Panmure-street, Dundee.
1858. ‡Wardle, Thomas, F.G.S. Leek Brook, Leek, Staffordshire.
1884.§§Wardwell, George J. 31 Grove-street, Rutland, Vermont, U.S.A.
1887. *Waring, Richard S. Pittsburg, Pennsylvania, U.S.A.
1878. §WARINGTON, ROBERT, F.R.S., F.C.S., Professor of Rural Economy in the University of Oxford. High Bank, Harpenden, St. Albans, Herts.
1882. ‡Warner, F. I., F.L.S. 20 Hyde-street, Winchester.
1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.
1875. ‡Warren, Algernon. 6 Windsor-terrace, Clifton, Bristol.
1887. ‡WARREN, Major-General Sir CHARLES, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. Athenæum Club, London, S.W.
1893. ‡Warwick, W. D. Balderton House, Newark-on-Trent.
1875. *Waterhouse, Lieut.-Colonel J. 15 West Chislehurst Park, Eltham, Kent.
1870. ‡Waters, A. T. H., M.D. 60 Bedford-street, Liverpool.
1892. ‡Waterston, James H. 37 Lutton-place, Edinburgh.
1875. ‡Watherston, Rev. Alexander Law, M.A., F.R.A.S. The Grammar School, Hinckley, Leicestershire.
1881. §Watherston, E. J. 12 Pall Mall East, London, S.W.
1887. ‡Watkin, F. W. 46 Auriol-road, West Kensington, London, W.
1884. ‡Watson, A. G., D.C.L. Uplands, Wadhurst, Sussex.
1886. *Watson, C. J. 34 Smallbrook-street, Birmingham.
1883. ‡Watson, C. Knight, M.A. Society of Antiquaries, Burlington House London, W.
1892. §Watson, G. Athenæum-buildings, Park-lane, Leeds.
1885. ‡Watson, Deputy Surgeon-General G. A. Hendre, Overton Park, Cheltenham.
1882. ‡WATSON, Rev. H. W., D.Sc., F.R.S. Berkeswell Rectory, Coventry.
1887. ‡*Watson, J. Beauchamp. Gilt Hall, Carlisle.*
1884. ‡Watson, John. Queen's University, Kingston, Ontario, Canada.
1889. ‡Watson, John, F.I.C. 5 Loraine-terrace, Low Fell, Gateshead.
1863. ‡Watson, Joseph. Bensham-grove, Gateshead.
1863. ‡Watson, R. Spence, LL.D., F.R.G.S. Bensham-grove, Gateshead.
1867. ‡Watson, Thomas Donald. 16 St. Mary's-road, Bayswater, London, W.
1892. §Watson, William, M.D. Slateford, Midlothian.

Year of Election.

1879. *WATSON, WILLIAM HENRY, F.C.S., F.G.S. Braystones, Cumberland.
1894. *Watson, W. 7 Upper Cheyne-walk, London, S.W.
1882. ‡Watt, Alexander. 89 Hartington-road, Sefton Park, Liverpool.
1884. ‡Watt, D. A. P. 284 Upper Stanley-street, Montreal, Canada.
1869. ‡Watt, Robert B. E., F.R.G.S. Ashley-avenue, Belfast.
1888. ‡WATTS, B. H. 10 Rivers-street, Bath.
1891. *Watts, E. Hannay, F.R.G.S. Springfield, Newport, Monmouthshire.
1875. *WATTS, JOHN, B.A., D.Sc. Merton College, Oxford.
1884. *Watts, Rev. Robert R. Stourpaine Vicarage, Blandford.
1870. §§Watts, William, F.G.S. Oldham Corporation Waterworks, Piethorn, near Rochdale.
1873. *WATTS, W. MARSHALL, D.Sc. Giggleswick Grammar School, near Settle.
1883. *WATTS, W. W., M.A., F.G.S. Geological Survey Office, Jermyn-street, London, S.W.; and Corndon, Worcester-road, Sutton, Surrey.
1891. ‡Waugh, James. Higher Grade School, 110 Newport-road, Cardiff.
1869. ‡Way, Samuel James. Adelaide, South Australia.
1883. ‡Webb, George. 5 Tenterden-street, Bury, Lancashire.
1871. ‡Webb, Richard M. 72 Grand-parade, Brighton.
1890. ‡Webb, Sidney. 4 Park-village East, London, N.W.
1866. *WEBB, WILLIAM FREDERICK, F.G.S., F.R.G.S. Newstead Abbey, near Nottingham.
1886. §WEBBER, Major-General C. E., C.B., M.Inst.C.E. 17 Egerton-gardens, London, S.W.
1891. §§Webber, Thomas. Kensington Villa, 6 Salisbury-road, Cardiff.
1859. ‡Webster, John. Edgehill, Aberdeen.
1834. ‡Webster, Richard, F.R.A.S. 6 Queen Victoria-street, London, E.C.
1882. *Webster, Sir Richard Everard, LL.D., Q.C., M.P. Hornton Lodge, Hornton-street, Kensington, London, S.W.
1889. **Webster, William, F.C.S. 50 Lee Park, Lee, Kent.*
1884. *Wedekind, Dr. Ludwig, Professor of Mathematics at Karlsruhe. Karlsruhe.
1889. ‡Weeks, John G. Bedlington.
1890. *Weiss, F. Ernest, B.Sc., F.L.S., Professor of Botany in Owens College, Manchester.
1886. ‡Weiss, Henry. Westbourne-road, Birmingham.
1865. ‡Welch, Christopher, M.A. United University Club, Pall Mall East, London, S.W.
1894. §Weld, Miss. Conal More, Norham Gardens, Oxford.
1876. *WELDON, W. F. R., M.A., F.R.S., Professor of Comparative Anatomy and Zoology in University College, London. 30A Wimpole-street, London, W.
1880. *Weldon, Mrs. 30A Wimpole-street, London, W.
1881. §§Wellcome, Henry S. First Avenue Hotel, Holborn, London, W.C.
1879. §WELLS, CHARLES A., A.I.E.E. 219 High-street, Lewes.
1881. §Wells, Rev. Edward, B.A. West Dean Rectory, Salisbury.
1894. §§Wells, J. G. Selwood House, Shobnall-street, Burton-on-Trent.
1883. ‡Welsh, Miss. Girton College, Cambridge.
1887. *Welton, T. A. 38 St. John's-road, Brixton, London, S.W.
1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
1881. *Wenlock, The Right Hon. Lord. Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.

Year of Election.

1864. *Were, Anthony Berwick. Hensingham, Whitehaven, Cumberland.
1886. §Wertheimer, Julius, B.A., B.Sc., F.C.S., Professor of Chemistry in the Merchant Venturers' Technical College, Bristol.
1865. ‡Wesley, William Henry. Royal Astronomical Society, Burlington House, London, W.
1853. ‡West, Alfred. Holderness-road, Hull.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1853. ‡ *West, Stephen. Hessle Grange, near Hull.*
1882. *Westlake, Ernest, F.G.S. Vale of Health, Hampstead, London, N.W.
1882. ‡Westlake, Richard. Portswood, Southampton.
1882. ‡WETHERED, EDWARD, F.G.S. 4 St. Margaret's-terrace, Cheltenham.
1884. ‡Wharton, E. R., M.A. 4 Broad-street, Oxford.
1885. *WHARTON, Admiral W. J. L., C.B., R.N., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty. Florys, Prince's-road, Wimbledon Park, Surrey.
1888. ‡Wheatcroft, William G. 6 Widcombe-terrace, Bath.
1853. ‡Wheatley, E. B. Cote Wall, Mirfield, Yorkshire.
1866. ‡Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London, N.W.
1884. ‡Wheeler, Claude L., M.D. 251 West 52nd-street, New York City, U.S.A.
1883. *Wheeler, George Brash. Elm Lodge, Wickham-road, Beckenham, Kent.
1878. *Wheeler, W. H., M.Inst.C.E. Wyncote, Boston, Lincolnshire.
1888. §Whelen, John Leman. Bank House, 16 Old Broad-street, London, E.C.
1883. ‡Whelpton, Miss K. Newnham College, Cambridge.
1893. *WHETHAM, W. C. D., M.A. Trinity College, Cambridge.
1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.
1888. *Whidborne, Miss Constance Mary. Charanté, Torquay.
1879. *WHIDBORNE, Rev. GEORGE FERRIS, M.A., F.G.S. St. George's Vicarage, Battersea Park-road, London, S.W.
1874. ‡Whitaker, Henry, M.D. Fortwilliam Terrace, Belfast.
1883. *Whitaker, T. Savile Heath, Halifax.
1859. *WHITAKER, WILLIAM, B.A., F.R.S., F.G.S. Geological Survey Office, Jermyn-street, London, S.W.; and 33 East Park-terrace, Southampton.
1884. ‡Whitcher, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.
1886. ‡Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham.
1886. ‡White, Alderman, J.P. Sir Harry's-road, Edgbaston, Birmingham.
1876. ‡White, Angus. Easdale, Argyllshire.
1886. ‡White, A. Silva. 47 Clanricarde-gardens, London, W.
1883. ‡White, Charles. 23 Alexandra-road, Southport.
1882. ‡White, Rev. George Cecil, M.A. Nutshalling Rectory, Southampton.
1885. *White, J. Martin. Balruddery, near Dundee.
1873. ‡White, John. Medina Docks, Cowes, Isle of Wight.
1859. ‡WHITE, JOHN FORBES. 311 Union-street, Aberdeen.
1883. ‡White, John Reed. Rossall School, near Fleetwood.
1865. ‡White, Joseph. Regent-street, Nottingham.
1895. §White, Philip J., M.B., Professor of Zoology in University College, Bangor, North Wales.
1884. ‡White, R. 'Gazette' Office, Montreal, Canada.
1859. ‡White, Thomas Henry. Tandragee, Ireland.

Year of Election.

1877. *White, William. 66 Cambridge-gardens, Notting Hill, London, W.
1883. *White, Mrs. 66 Cambridge-gardens, Notting Hill, London, W.
1886. *White, William. The Ruskin Museum, Sheffield.
1883. ‡Whitehead, P. J. 6 Cross-street, Southport.
1893. §Whiteley, R. Lloyd, F.C.S., F.I.C. 20 Beeches-road, West Bromwich.
1881. ‡Whitfield, John, F.C.S. 113 Westborough, Scarborough.
1852. ‡Whitla, Valentine. Beneden, Belfast.
1891. §Whitmell, Charles Thomas, M.A., B.Sc., F.G.S. 47 Park-place, Cardiff.
1857. *WHITTY, Rev. JOHN IRWINE, M.A., D.C.L., LL.D. 1 Rodbourne-villas, Crescent-road, Ramsgate.
1887. ‡Whitwell, William. Overdene, Saltburn-by-the-Sea.
1874. *Whitwill, Mark. Lynthorpe, Tyndall's Park, Bristol.
1883. ‡Whitworth, James. 88 Portland-street, Southport.
1870. ‡Whitworth, Rev. W. Allen, M.A. 7 Margaret-street, London, W.
1892. §Whyte, Peter, M.Inst.C.E. 3 Clifton-terrace, Edinburgh.
1888. ‡Wickham, Rev. F. D. C. Horsington Rectory, Bath.
1865. ‡Wiggin, Sir Henry, Bart. Metchley Grange, Harborne, Birmingham.
1886. ‡Wiggin, Henry A. The Lea, Harborne, Birmingham.
1883. ‡Wigglesworth, Mrs. Ingleside, West-street, Scarborough.
1881. *Wigglesworth, Robert. Beckwith Knowle, near Harrogate.
1878. ‡Wigham, John R. Albany House, Monkstown, Dublin.
1889. *Wilberforce, L. R., M.A. Trinity College, Cambridge.
1881. ‡WILBERFORCE, W. W. Fishergate, York.
1887. ‡Wild, George. Bardsley Colliery, Ashton-under-Lyne.
1887. *WILDE, HENRY, F.R.S. The Hurst, Alderley Edge, Manchester.
1887. ‡Wilkinson, C. H. Slaithwaite, near Huddersfield.
1857. ‡Wilkinson, George. Temple Hill, Killiney, Co. Dublin.
1892. ‡Wilkinson, Rev. J. Frome. Barley Rectory, Royston, Herts.
1886. *Wilkinson, J. H. Hamstead Hill, Handsworthy, Birmingham.
1879. ‡Wilkinson, Joseph. York.
1887. *Wilkinson, Thomas Read. The Polygon, Ardwick, Manchester.
1872. ‡Wilkinson, William. 168 North-street, Brighton.
1890. ‡Willans, J. W. Kirkstall, Leeds.
1872. ‡WILLETT, HENRY, F.G.S. Arnold House, Brighton.
1891. ‡Williams, Arthur J., M.P. Coedymwstwr, near Bridgend.
1861. *Williams, Charles Theodore, M.A., M.B. 2 Upper Brook-street, Grosvenor-square, London, W.
1887. ‡Williams, Sir E. Leader, M.Inst.C.E. The Oaks, Altrincham.
1883. *Williams, Edward Starbuck. Ty-ar-y-graig, Swansea.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 6 Heathfield, Swansea.
1875. *Williams, Rev. Herbert Addams. Llangibby Rectory, near Newport, Monmouthshire.
1883. ‡Williams, Rev. H. Alban, M.A. Christ Church, Oxford.
1857. ‡Williams, Rev. James. Llanfairinghornwy, Holyhead.
1888. ‡Williams, James. Bladud Villa, Entryhill, Bath.
1891. §Williams, J. A. B., M.Inst.C.E. Midwood, Christchurch-road, Bournemouth.
1887. ‡Williams, J. Francis, Ph.D. Salem, New York, U.S.A.
1888. *Williams, Miss Katherine. Llandaff House, Pembroke Vale, Clifton, Bristol.
1875. *Williams, M. B. Killay House, near Swansea.
1879. ‡WILLIAMS, MATTHEW W., F.C.S. 26 Elizabeth-street, Liverpool.
1891. ‡Williams, Morgan. 5 Park-place, Cardiff.
1886. ‡Williams, Richard, J.P. Brunswick House, Wednesbury.

Year of Election.

1883. ‡Williams, R. Price. North Brow, Primrose Hill, London, N.W.
1883. ‡Williams, T. H. 21 Strand-street, Liverpool.
1888. ‡Williams, W. Cloud House, Stapleford, Nottinghamshire.
1877. *WILLIAMS, W. CARLETON, F.C.S. Firth College, Sheffield.
1883. ‡Williamson, Miss. Sunnybank, Ripon, Yorkshire.
1850. *WILLIAMSON, ALEXANDER WILLIAM, Ph.D., LL.D., D.C.L., F.R.S., F.C.S., Corresponding Member of the French Academy. High Pitfold, Haslemere.
1857. ‡WILLIAMSON, BENJAMIN, M.A., D.C.L., F.R.S. Trinity College, Dublin.
1876. ‡Williamson, Rev. F. J. Ballantrae, Girvan, N.B.
1863. ‡Williamson, John. South Shields.
1895.§§WILLINK, W. (LOCAL SECRETARY). Liverpool.
1882. ‡Willmore, Charles. Queenwood College, near Stockbridge, Hants.
1859. *Wills, The Hon. Sir Alfred. Chelsea Lodge, Tite-street, London, S.W.
1886. ‡Wills, A. W. Wylde Green, Erdington, Birmingham.
1895. §Willis, John C., M.A., Senior Assistant in Botany in Glasgow University. 8i Lawrence-place, Dowanhill, Glasgow.
1886. ‡Wilson, Alexander B. Holywood, Belfast.
1885. ‡Wilson, Alexander H. 2 Albyn-place, Aberdeen.
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. Free Church Manse, North Queensferry.
1876. ‡Wilson, Dr. Andrew. 118 Gilmore-place, Edinburgh.
1894. *Wilson, Charles J., F.I.C., F.C.S. 19 Little Queen-street, Westminster, S.W.
1874. ‡WILSON, Major-General Sir C. W., R.E., K.C.B., K.C.M.G., D.C.L., F.R.S., F.R.G.S. The Athenæum Club, London, S.W.
1876. ‡Wilson, David. 124 Bothwell-street, Glasgow.
1890. ‡Wilson, Edmund. Denison Hall, Leeds.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, Frederick. 99 Albany-street, Regent's-park, London, N.W.
1875. ‡WILSON, GEORGE FERGUSSON, F.R.S., F.C.S., F.L.S. Heatherbank, Weybridge Heath, Surrey.
1874. *Wilson, George Orr. Dunardagh, Blackrock, Co. Dublin.
1863. ‡Wilson, George W. Heron Hill, Hawick, N.B.
1895. §Wilson, Gregg. The University, Edinburgh.
1883. *Wilson, Henry, M.A. Farnborough Lodge, R.S.O., Kent.
1879. ‡Wilson, Henry J. 255 Pitsmoor-road, Sheffield.
1885. ‡Wilson, J. Dove, LL.D. 17 Rubislaw-terrace, Aberdeen.
1886. ‡Wilson, J. E. B. Woodslee, Wimbledon, Surrey.
1890. ‡Wilson, J. Mitchell, M.D. 51 Hall Gate, Doncaster.
1865. ‡WILSON, Ven. JAMES M., M.A., F.G.S. The Vicarage, Rochdale.
1884. ‡Wilson, James S. Grant. Geological Survey Office, Sheriff Court-buildings, Edinburgh.
1879. ‡Wilson, John Wycliffe. Eastbourne, East Bank-road, Sheffield.
1894.§§Wilson, Rev. R. J., M.A., Warden of Keble College, Oxford. Oxford.
1876. ‡Wilson, R. W. R. St. Stephen's Club, Westminster, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1892.§§Wilson, T. Stacey, M.D. Wyddrington, Edgbaston, Birmingham.
1861. ‡Wilson, Thos. Bright. 4 Hope View, Fallowfield, Manchester.
1887. §Wilson, W., jun. Hillock, Terpersie, by Alford, Aberdeenshire.
1871. *Wilson, William E. Daramona House, Streete, Rathowen, Ireland.

Year of
Election.

1861. *WILTSHIRE, Rev. THOMAS, M.A., F.G.S., F.L.S., F.R.A.S., Professor of Geology and Mineralogy in King's College, London. 25 Granville-park, Lewisham, London, S.E.
1877. ‡Windeatt, T. W. Dart View, Totnes.
1886. ‡WINDLE, BERTRAM C. A., M.A., M.D., D.Sc., Professor of Anatomy in Mason College, Birmingham.
1887. ‡Windsor, William Tessimond. Sandiway, Ashton-on-Mersey.
1893. *Winter, G. K., M.Inst.C.E., F.R.A.S. Arkonam, Madras, India.
1863. *WINWOOD, Rev. H. H., M.A., F.G.S. 11 Cavendish-crescent, Bath.
1894.§§Witley, Arthur. 17 Acton-lane, Harlesden, London, N.W.
1888. ‡WODEHOUSE, E. R., M.P. 56 Chester-square, London, S.W.
1883. ‡Wolfenden, Samuel. Cowley Hill, St. Helens, Lancashire.
1884. ‡Womack, Frederick, Lecturer on Physics and Applied Mathematics at St. Bartholomew's Hospital. 68 Abbey-road, London, N.W.
1881. *Wood, Alfred John. 5 Cambridge-gardens, Richmond, Surrey.
1883. §Wood, Mrs. A. J. 5 Cambridge-gardens, Richmond, Surrey.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1861. *Wood, Edward T. Blackhurst, Brinscall, Chorley, Lancashire.
1883. ‡Wood, Miss Emily F. Egerton Lodge, near Bolton, Lancashire.
1875. *Wood, George William Rayner. Memorial Hill, Albert-square, Manchester.
1878. ‡WOOD, Sir H. TRUEMAN, M.A. Society of Arts, John-street, Adelphi, London, W.C.
1883. *WOOD, JAMES, LL.D. Grove House, Scarisbrick-street, Southport.
1881. ‡Wood, John, B.A. Wharfedale College, Boston Spa, Yorkshire.
1883. *Wood, J. H. Hazelwood, 14 Lethbridge-road, Southport.
1886. ‡*Wood, Rev. Joseph. Carpenter-road, Birmingham.*
1893. ‡Wood, Joseph T. 29 Muster's-road, West Bridgeford, Nottinghamshire.
1883. ‡Wood, Mrs. Mary. Care of E. P. Sherwood, Esq., Holmes Villa, Rotherham.
1864. ‡Wood, Richard, M.D. Driffield, Yorkshire.
1890. *Wood, Robert H., M.Inst.C.E. 15 Bainbrigge-road, Headingley, Leeds.
1871. ‡Wood, Provost T. Baileyfield, Portobello, Edinburgh.
1850. ‡Wood, Rev. Walter. Elie, Fife.
1872. ‡Wood, William Robert. Carlisle House, Brighton.
1845. *Wood, Rev. William Spicer, M.A., D.D. Higham, Rochester.
1863. *WOODALL, JOHN WOODALL, M.A., F.G.S. St. Nicholas House, Scarborough.
1884. ‡Woodbury, C. J. H. 31 Milk-street, Boston, U.S.A.
1883. ‡Woodcock, Herbert S. The Elms, Wigan.
1884. ‡Woodcock, T., M.A. 150 Cromwell-road, London, S.W.
1884. ‡Woodd, Arthur B. Woodlands, Hampstead, London, N.W.
1888. *Woodiwiss, Mrs. Alfred. Hulme House, Cheadle Hulme, near Stockport.
1872. ‡Woodman, James. 26 Albany-villas, Hove, Sussex.
*WOODS, EDWARD, M.Inst.C.E. 8 Victoria-street, Westminster, London, S.W.
1883. ‡Woods, Dr. G. A., F.R.S.E., F.R.M.S. 16 Adelaide-street, Leamington.
WOODS, SAMUEL. 1 Drapers'-gardens, Throgmorton-street, London, E.C.
1888. ‡Woodthorpe, Colonel. Messrs. King & Co., 45 Pall Mall, London, S.W.

Year of Election.

1887. *Woodward, Arthur Smith, F.L.S., F.G.S., Assistant Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, London, S.W.

1869. *Woodward, C. J., B.Sc., F.G.S. 97 Harborne-road, Birmingham.

1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, London, S.W.

1866. ‡Woodward, Henry, LL.D., F.R.S., F.G.S., Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, London, S.W.

1870. ‡Woodward, Horace B., F.G.S. Geological Museum, Jermyn-street, London, S.W.

1894. *Woodward, John Harold. 6 Brighton-terrace, Merridale-road, Wolverhampton.

1884. *Woolcock, Henry. Rickerby House, St. Bees.

1890. §Woollcombe, Robert Lloyd, M.A., LL.D., F.I.Inst., F.S.S., M.R.I.A., F.R.S.A. (Ireland). 14 Waterloo-road, Dublin.

1877. ‡Woollcombe, Surgeon-Major Robert W. 14 Acre-place, Stoke, Devonport.

1883. *Woolley, George Stephen. Victoria Bridge, Manchester.

1856. ‡Woolley, Thomas Smith, jun. South Collingham, Newark.

1874. ‡Workman, Charles. Ceara, Windsor, Belfast.

1878. ‡Wormell, Richard, M.A., D.Sc. Roydon, near Ware, Hertfordshire.

1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.

1855. *Worthington, Rev. Alfred William, B.A. Old Swinford, Stourbridge, Worcestershire.

Worthington, James. Sale Hall, Ashton-on-Mersey.

1856. ‡Worthy, George S. 2 Arlington-terrace, Mornington-crescent, Hampstead-road, London, N.W.

1884. ‡Wragge, Edmund. 109 Wellesley-street, Toronto, Canada.

1879. ‡Wrentmore, Francis. 34 Holland Villas-road, Kensington, London, S.W.

1883. *Wright, Rev. Arthur, M.A. Queen's College, Cambridge.

1883. *Wright, Rev. Benjamin, M.A. Sandon Rectory, Chelmsford.

1890. ‡Wright, Dr. C. J. Virginia-road, Leeds.

1857. ‡Wright, E. Perceval, M.A., M.D., F.L.S., M.R.I.A., Professor of Botany and Director of the Museum, Dublin University. 5 Trinity College, Dublin.

1886. ‡Wright, Frederick William. 4 Full-street, Derby.

1884. ‡Wright, Harrison. Wilkes' Barré, Pennsylvania, U.S.A.

1876. ‡Wright, James. 114 John-street, Glasgow.

1865. ‡Wright, J. S. 168 Brearley-street West, Birmingham.

1884. ‡Wright, Professor R. Ramsay, M.A., B.Sc. University College, Toronto, Canada.

1831. Wright, T. G., M.D. 91 Northgate, Wakefield.

1876. ‡Wright, William. 31 Queen Mary-avenue, Glasgow.

1871. ‡Wrightson, Thomas, M.P., M.Inst.C.E., F.G.S. Norton Hall, Stockton-on-Tees.

1887. ‡Wrigley, Rev. Dr., M.A., M.D., F.R.A.S. 15 Gauden-road, London, S.W.

1876. ‡Wünsch, Edward Alfred, F.G.S. Carharrack, Scorrier, Cornwall.

1892. ‡*Wyld, Norman. University Hall, Edinburgh.*

1883. §Wyllie, Andrew. 1 Leicester-street, Southport.

1885. ‡Wyness, James D., M.D. 349 Union-street, Aberdeen.

1871. ‡Wynn, Mrs. Williams. Cefn, St. Asaph.

1862. ‡Wynne, Arthur Beevor, F.G.S. Geological Survey Office, 14 Hume-street, Dublin.

Year of Election.

1875. ‡Yabbicom, Thomas Henry. 37 White Ladies-road, Clifton, Bristol.
*Yarborough, George Cook. Camp's Mount, Doncaster.
1894. *Yarrow, A. F. Poplar, London, E.
1883. §Yates, James. Public Library, Leeds.
1867. ‡Yeaman, James. Dundee.
1887. ‡Yeats, Dr. Chepstow.
1884. ‡Yee, Fung. Care of R. E. C. Fittock, Esq., Shanghai, China.
1877. ‡Yonge, Rev. Duke. Puslinch, Yealmpton, Devon.
1891. ‡Yorath, Alderman T. V. Cardiff.
1884. ‡York, Frederick. 87 Lancaster-road, Notting Hill, London, W.
1891. §Young, Alfred C., F.C.S. 64 Tyrwhitt-road, St. John's, London, S.E.
1886. *Young, A. H., M.B., F.R.C.S., Professor of Anatomy in Owens College, Manchester.
1894. *Young, George, Ph.D. Firth College, Sheffield.
1884. ‡Young, Sir Frederick, K.C.M.G. 5 Queensberry-place, London, S.W.
1884. ‡Young, Professor George Paxton. 121 Bloor-street, Toronto, Canada.
1876. ‡Young, John, M.D., Professor of Natural History in the University of Glasgow. 38 Cecil-street, Hillhead, Glasgow.
1885. ‡Young, R. Bruce. 8 Crown-gardens, Dowanhill, Glasgow.
1886. §Young, R. Fisher. New Barnet, Herts.
1883. *Young, Sydney, D.Sc., F.R.S., F.C.S., Professor of Chemistry in University College, Bristol.
1887. ‡Young, Sydney. 29 Mark-lane, London, E.C.
1890. ‡Young, T. Graham, F.R.S.E. Westfield, West Calder, Scotland.
1868. ‡Youngs, John. Richmond Hill, Norwich.

1886. ‡Zair, George. Arden Grange, Solihull, Birmingham.
1886. ‡Zair, John. Merle Lodge, Moseley, Birmingham.

CORRESPONDING MEMBERS.

Year of Election.

1887. Professor Cleveland Abbe. Weather Bureau, Department of Agriculture, Washington, United States.
1892. Svante Arrhenius. The University, Stockholm.
1881. Professor G. F. Barker. University of Pennsylvania, Philadelphia, United States.
1894. Professor F. Beilstein. Technological Institute, St. Petersburg.
1894. Professor E. van Beneden. The University, Liége, Belgium.
1887. Professor A. Bernthsen, Ph.D. Mannheim, L 11, 3, Germany.
1892. Professor M. Bertrand. L'École des Mines, Paris.
1894. Deputy Surgeon-General J. S. Billings. Washington, United States.
1893. Professor Christian Bohr. 62 Bredgade, Copenhagen.
1880. Professor Ludwig Boltzmann. Vienna.
1887. His Excellency R. Bonghi. Rome.
1887. Professor Lewis Boss. Dudley Observatory, Albany, New York, United States.
1884. Professor H. P. Bowditch, M.D. Boston, Massachusetts, United States.
1890. Professor Brentano. 1 Maximilian-platz, München.
1893. Professor W. C. Brögger. Universitets Mineralogske Institute, Christiania.
1887. Professor J. W. Brühl. Heidelberg.
1884. Professor George J. Brush. Yale College, New Haven, United States.
1894. Professor D. H. Campbell. Stanford University, Palo Alto, California, United States.
1887. Professor G. Capellini. Royal University of Bologna.
1887. Professor J. B. Carnoy. Rue du Canal 22, Louvain.
1887. Dr. H. Caro. Mannheim.
1894. Emile Cartailhac. Toulouse, France.
1861. Dr. Carus. Leipzig.
1894. Dr. A. Chauveau. The Sorbonne, Paris.
1887. F. W. Clarke. United States Geological Survey, Washington, United States.
1855. Professor Dr. Ferdinand Cohn. The University, Breslau, Prussia.
1873. Professor Guido Cora. 74 Corso Vittorio Emanuele, Turin.
1880. Professor Cornu. Rue de Grenelle 9, Paris.
1870. J. M. Crafts, M.D. L'École des Mines, Paris.
1876. Professor Luigi Cremona. The University, Rome.
1889. W. H. Dall. United States Geological Survey, Washington, United States.
1862. Wilhelm Delffs, Professor of Chemistry in the University of Heidelberg.
1864. M. Des Cloizeaux. Rue de Monsieur 13, Paris.

Year of Election.

1872. Professor G. Dewalque. Liége, Belgium.
1870. Dr. Anton Dohrn. Naples.
1890. Professor V. Dwelshauvers-Dery. Liége, Belgium.
1876. Professor Alberto Eccher. Florence.
1894. Professor W. Einthoven. Leiden.
1892. Professor F. Elfving. Helsingfors, Finland.
1894. Professor T. W. W. Engelmann. Utrecht.
1892. Professor Léo Errera. 1 Place Stephanie, Brussels.
1874. Dr. W. Feddersen. 9 Carolinenstrasse, Leipzig.
1886. Dr. Otto Finsch. Bremen.
1887. Professor Dr. R. Fittig. Strasburg.
1894. Professor Wilhelm Foerster. Encke Platz 3A, Berlin, S.W., Germany.
1872. W. de Fonvielle. 50 Rue des Abbesses, Paris.
1894. Professor Léon Fredericq. Liége, Belgium.
1894. Professor C. Friedel. 9 Rue Michelet, Paris.
1887. Professor Dr. Anton Fritsch. The University, Prague.
1892. Professor Dr. Gustav Fritsch. The University, Berlin.
1881. Professor C. M. Gariel. 6 Rue Edouard Detaille, Paris.
1866. Dr. Gaudry. 57 Rue Cuvier, Paris.
1861. Dr. Geinitz, Professor of Mineralogy and Geology. Dresden.
1884. Professor J. Willard Gibbs. Yale College, New Haven, United States.
1884. Professor Wolcott Gibbs. Harvard University, Cambridge, Massachusetts, United States.
1889. G. K. Gilbert. United States Geological Survey, Washington, United States.
1892. Daniel C. Gilman. Johns Hopkins University, Baltimore, United States.
1870. William Gilpin. Denver, Colorado, United States.
1889. Professor Gustave Gilson. Louvain.
1889. A. Gobert. 222 Chaussée de Charleroi, Brussels.
1876. Dr. Benjamin A. Gould. Cambridge, Massachusetts, United States.
1884. General A. W. Greely, LL.D. Washington, United States.
1892. Dr. C. E. Guillaume. Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres.
1876. Professor Ernst Haeckel. Jena.
1889. Horatio Hale. Clinton, Ontario, Canada.
1881. Dr. Edwin H. Hall. 37 Gorham-street, Cambridge, U.S.A.
1872. Professor James Hall. Albany, State of New York.
1889. Dr. Max von Hantken. Budapesth.
1887. Fr. von Hefner-Alteneck. Berlin.
1893. Professor Paul Heger. The University, Brussels.
1894. Professor Ludimar Hermann. The University, Königsberg, Prussia.
1893. Professor Richard Hertwig. Munich.
1893. Professor Hildebrand. Stockholm.
1887. Professor W. His. Leipzig.
1881. Professor A. A. W. Hubrecht, LL.D., C.M.Z.S. Utrecht.
1887. Dr. Oliver W. Huntington. Harvard University, Cambridge, Massachusetts, United States.
1884. Professor C. Loring Jackson. Harvard University, Cambridge, Massachusetts, United States.
1867. Dr. J. Janssen, LL.D. The Observatory, Meudon, Seine-et-Oise.
1876. Dr. W. J. Janssen. Villa Frisia, Aroza, Graubünden, Switzerland.
1881. W. Woolsey Johnson, Professor of Mathematics in the United States Naval Academy. Annapolis, United States.
1887. Professor C. Julin. Liége.
1876. Dr. Giuseppe Jung. 7 Via Principe Umberto, Milan.

Year of Election.

1877. M. Akin Kàroly. 92 Rue Richelieu, Paris.
1862. Aug. Kekulé, Professor of Chemistry. Bonn.
1884. Professor Dairoku Kikuchi, M.A. Imperial University, Tokio, Japan.
1873. Dr. Felix Klein. The University, Göttingen.
1894. Professor L. Kny. The University, Berlin.
1856. Professor A. von Kölliker. Würzburg, Bavaria.
1894. Professor J. Kollman. Basle, Switzerland.
1887. Professor Dr. Arthur König. Physiological Institute, The University, Berlin.
1894. Maxime Kovalevsky. Beaulieu-sur-Mer, Alpes-Maritimes.
1887. Professor Krause. 31 Brueckenallee, Berlin.
1877. Dr. Hugo Kronecker, Professor of Physiology. The University, Bern, Switzerland.
1887. Lieutenant R. Kund. German African Society, Berlin.
1887. Professor A. Ladenburg. Breslau.
1887. Professor J. W. Langley. 847½ Fairmount-street, Cleveland, Ohio, United States.
1882. Dr. S. P. Langley, D.C.L., Secretary of the Smithsonian Institution. Washington, United States.
1887. Professor Count Solms Laubach. Strassburg.
1887. Dr. Leeds, Professor of Chemistry at the Stevens Institute, Hoboken, New Jersey, United States.
1872. M. Georges Lemoine. 76 Rue d'Assas, Paris.
1887. Professor A. Lieben. Vienna.
1883. Dr. F. Lindemann. 42 Georgenstrasse, Munich.
1877. Dr. M. Lindemann, Hon. Sec. of the Bremen Geographical Society. Bremen.
1887. Professor Dr. Georg Lunge. The University, Zurich.
1871. Professor Jacob Lüroth. The University, Freiburg, Germany.
1871. Dr. Lütken. Copenhagen.
1894. Dr. Otto Maas. The University, Munich.
1887. Dr. Henry C. McCook. Philadelphia, United States.
1867. Professor Mannheim. Rue de la Pompe 11, Passy, Paris.
1881. Professor O. C. Marsh. Yale College, New Haven, United States.
1887. Dr. C. A. Martius. Berlin.
1890. Professor E. Mascart, Membre de l'Institut. 176 Rue de l'Université, Paris.
1894. Professor A. M. Mayer. Stevens Institute of Technology, Hoboken, New Jersey, United States.
1887. Professor D. I. Mendeléeff, D.C.L. St. Petersburg.
1887. Professor N. Menschutkin. St. Petersburg.
1884. Albert A. Michelson. Cleveland, Ohio, United States.
1848. Professor J. Milne-Edwards. 57 Rue Cuvier, Paris.
1887. Dr. Charles Sedgwick Minot. Boston, Massachusetts, United States.
1894. Professor G. Mittag-Leffler. Stockholm.
1893. Professor H. Moissan. The Sorbonne, Paris.
1877. Professor V. L. Moissenet. L'École des Mines, Paris.
1894. Dr. Edmund von Mojsisovics. Strohgasse 26, Vienna.
1864. Dr. Arnold Moritz. The University, Dorpat, Russia.
1887. E. S. Morse. Peabody Academy of Science, Salem, Massachusetts, United States.
1889. Dr. F. Nansen. Christiania.
1894. Professor R. Nasini. The University, Padua, Italy.
1864. Herr Neumayer. Deutsche Seewarte, Hamburg.
1884. Professor Simon Newcomb. Washington, United States.
1869. Professor H. A. Newton. Yale College, New Haven, United States.

Year of Election.

1887. Professor Noelting. Mühlhausen, Elsass.
1894. Professor H. F. Osborn. Columbia College, New York, United States.
1894. Baron Osten-Sacken. Heidelberg.
1890. Professor W. Ostwald. Leipzig.
1889. Professor A. S. Packard. Brown University, Providence, Rhode Island, United States.
1890. Maffeo Pantaleoni, Director of the Royal Superior School of Commerce. Bari, Italy.
1887. Dr. Pauli. Höchst-on-Main, Germany.
1890. Professor Otto Pettersson. Hogskolas Laboratorium, Stockholm.
1894. Professor W. Pfeffer. The University, Leipzig.
1870. Professor Felix Plateau. 152 Chaussée de Courtrai, Gand.
1884. Major J. W. Powell, Director of the Geological Survey of the United States. Washington, United States.
1887. Professor W. Preyer. The University, Berlin.
1886. Professor Putnam, Secretary of the American Association for the Advancement of Science. Harvard University, Cambridge, Massachusetts, United States.
1887. Professor G. Quincke. Heidelberg.
1868. L. Radlkofer, Professor of Botany in the University of Munich.
1886. Rev. A. Renard. Rue du Roger, Gand, Belgium.
1873. Professor Baron von Richthofen. Kurfürstenstrasse 117, Berlin.
1892. Professor Rosenthal, M.D. Erlangen, Bavaria.
1890. A. Lawrence Rotch. Blue Hill Observatory, Readville, Massachusetts, United States.
1881. Professor Henry A. Rowland. Baltimore, United States.
1894. Professor P. H. Schoute. The University, Groningen, Holland.
1883. Dr. Ernst Schröder. Karlsruhe, Baden.
1874. Dr. G. Schweinfurth. Cairo.
1846. Baron de Selys-Longchamps. Liége, Belgium.
1873. Dr. A. Shafarik. Prague.
1876. Professor R. D. Silva. L'École Centrale, Paris.
1892. Dr. Maurits Snellen, Chief Director of the Royal Meteorological Institute of the Netherlands. Utrecht.
1887. Ernest Solvay. 25 Rue du Prince Albert, Brussels.
1888. Dr. Alfred Springer. Cincinnati, Ohio, United States.
1866. Professor Steenstrup. Copenhagen.
1889. Professor G. Stefanescu. Bucharest.
1881. Dr. Cyparissos Stephanos. The University, Athens.
1894. Professor E. Strasburger. The University, Bonn.
1881. Professor Dr. Rudolf Sturm. The University, Breslau.
1884. Professor Robert H. Thurston. Sibley College, Cornell University, Ithaca, New York, United States.
1864. Dr. Otto Torell, Professor of Geology in the University of Lund, Sweden.
1887. Dr. T. M. Treub. Java.
1887. Professor John Trowbridge. Harvard University, Cambridge, Massachusetts, United States.
Arminius Vámbéry, Professor of Oriental Languages in the University of Pesth, Hungary.
1890. Professor J. H. van't Hoff. Amsterdam.
1889. Wladimir Vernadsky. Mineralogical Museum, Moscow.
1886. Professor Jules Vuylsteke. 80 Rue de Lille, Menin, Belgium.
1894. General F. A. Walker. Massachusetts Institute of Technology, Boston, United States.
1887. Professor H. F. Weber. Zurich.

Year of Election.

1887. Professor Dr. Leonhard Weber. Kiel.
1887. Professor August Weismann. Freiburg-im-Breisgau, Baden.
1887. Dr. H. C. White. Athens, Georgia, United States.
1881. Professor H. M. Whitney. Beloit College, Wisconsin, United States.
1887. Professor E. Wiedemann. Erlangen. [C/o T. A. Barth, Johannisgasse, Leipzig.]
1874. Professor G. Wiedemann. Leipzig.
1887. Professor R. Wiedersheim. Freiburg-im-Breisgau, Baden.
1887. Professor J. Wislicenus. Liebigstrasse 18, Leipzig.
1887. Dr. Otto N. Witt. 33 Lindenallée, Westend-Charlottenburg, Berlin.
1876. Professor Adolph Wüllner. Aix-la-Chapelle.
1887. Professor C. A. Young. Princeton College, United States.
1887. Professor F. Zirkel. Leipzig.

LIST OF SOCIETIES AND PUBLIC INSTITUTIONS

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Cornwall, Royal Geological Society of.
Dublin, Geological Survey of Ireland.
——, Royal College of Surgeons in Ireland.
——, Royal Geological Society of Ireland.
——, Royal Irish Academy.
——, Royal Society of.
Dundee, University College.
Edinburgh, Royal Society of.
——, Royal Medical Society of.
——, Scottish Society of Arts.
Exeter, Albert Memorial Museum.
Glasgow Philosophical Society.
——, Institution of Engineers and Shipbuilders in Scotland.
Leeds, Mechanics' Institute.
——, Philosophical and Literary Society of.
Liverpool, Free Public Library and Museum.
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——, Chemical Society.
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——, East India Library.
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——, Geology, Museum of Practical, 28 Jermyn Street.
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London, Kew Observatory.
——, Linnean Society.
——, London Institution.
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——, Meteorological Office.
——, Royal Asiatic Society.
——, Royal Astronomical Society.
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——, Royal College of Surgeons.
——, Royal Engineers' Institute, Chatham.
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——, Royal Institution.
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——, Radcliffe Observatory.
Plymouth Institution.
Salford, Royal Museum and Library.
Sheffield, Firth College.
Southampton, Hartley Institution.
Stonyhurst College Observatory.
Swansea, Royal Institution of South Wales
Yorkshire Philosophical Society.

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Geneva............Natural History Society.
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Grätz ....Naturwissenschaftlicher Verein.
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—— ....Geological Society.
—— ....Royal Academy of Sciences.
—— ....School of Mines.
Pultova ....Imperial Observatory.
Rome ....Accademia dei Lincei.
—— ....Collegio Romano.
—— ....Italian Geographical Society.
—— ....Italian Society of Sciences.
St. Petersburg . University Library.
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Stockholm ......Royal Academy.
Turin ....Royal Academy of Sciences.
Utrecht ....University Library.
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—— ....Medical College.
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AFRICA.

Cape of Good Hope . . . The Royal Observatory.

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—— ...Smithsonian Institution.
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Adelaide . . . . The Colonial Government.
Brisbane . . . . Queensland Museum.
Sydney . . . . Public Works Department.
Victoria . . . . The Colonial Government.

NEW ZEALAND.

Canterbury Museum.

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